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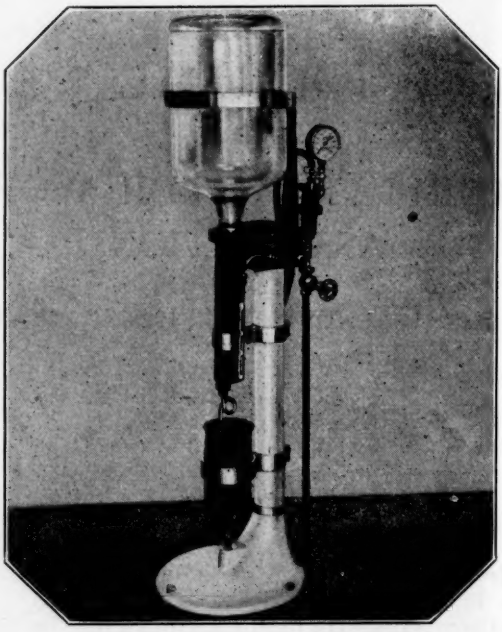

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CAST IRON SERVICE PIPE[1]

BY WM. W. HURLBUT[2]

The modern water works system of today undoubtedly occupies a position of the highest importance to the advancement of civilization. Among the various elements essential to this utility, probably none is more important than the service pipe. In fact, with the enormous increase of street paving, due to the rapid growth of our urban population throughout this country, the engineer is confronted with the realization of the excessive costs and wastes resultant from digging up of pavements to repair and replace services. This fact is further emphasized by the difficulty and annoyance of renewing services under the ever growing traffic conditions. Consequently more permanent service pipe materials are essential to eliminate this increasing maintenance cost. Such a material is found in cast iron pipe. Records in this country and in Europe do not extend far enough to determine the real life of cast iron pipe. It can only be stated that some of the cast iron pipe lines in France are now completing their third century of continuous service.

Small cast iron service pipe is not new in this country, having been in quite general use up to the time wrought iron and steel pipe were placed on the market in large quantities. Some of this pipe may still

[1] Presented before the Plant Management and Operation Division, San Francisco Convention, June 14, 1928.

[2] Office Engineer, Bureau of Water Works and Supply, Los Angeles, Calif.

be found in our eastern cities where it has been in use for approximately a century.

In those days the practice was to make a rigid connection with the main by the use of a cast iron ferrule. This method did not safeguard against increasing strains due to settlement and traffic. Moreover, in those times, cast iron pipe was comparatively expensive and was molded by hand without the use of machinery such as has been developed in modern times.

Under these conditions it was natural for users of service pipe to utilize the cheaper and more malleable materials when they were placed on the market. It has been demonstrated, however, over a period of time, that wrought iron and steel, as manufactured and protected, have a limited life underground. In fact their useful life is affected by oxidation due to bad soil conditions, chemical contents of water, poor drainage of the soil and electrolysis.

The life of cast iron pipe under bad soil conditions is so much longer than standard galvanized iron or steel pipe that no comparison can be made. To condemn it would mean the condemnation of cast iron pipe for water mains, which is the tried and accepted pipe for water works distributing systems.

The resumption of the use of small cast iron service pipe dates back approximately seven years. At that time very little 2-inch cast iron pipe was manufactured in this country. Most of it was made in weights and by processes which resulted in high costs. With the developments in modern foundry practice, in recent years, in the manufacture of small cast iron pipe, we now have available a service pipe moderately cheap and desirable. The reestablishment, use, and manufacture of small cast iron pipe are due largely to the efforts of Mr. J. R. McWane.

Cast iron service pipe certainly fulfills all of the essential requirements for a satisfactory service pipe. These are briefly as follows:

1. The water passing through the pipe is not affected in any manner as to make it injurious to the health of the consumer.

2. The pipe does not impart any objectionable taste or odor to the water passing through it.

3. It has adequate capacity to give satisfactory service at all times.

4. It has strength, durability and a high resistance to electrolysis.

5. It is easily installed and moderate in cost. We now find that this pipe is being used to a greater or less extent by towns and cities throughout this country.

PRACTICE IN LOS ANGELES

The Bureau of Water Works and Supply of the City of Los Angeles initiated the use of small cast iron service pipe in January, 1924, and installed services throughout the city under varying conditions. As the results obtained were very satisfactory, cast iron service pipe has been adopted as a standard. Since that date 1,28,000 feet or 242 miles of 2-inch cast iron pipe have been purchased, of which 1,120,000 feet or 212 miles have been installed, or at the rate of 250,000 feet annually. With an average of 20 feet to the service, this footage represents approximately 56,000 installations, or 20 per cent of the services.

The pipe is cast in 5-foot lengths which facilitates handling and provides sufficient joints to give flexibility to the line. It is of 2-inches inside diameter, $\frac{1}{4}$-inch wall thickness and weighs approximately 6 pounds to the lineal foot. The pipe is tested and guaranteed by the manufacturer to operate under 350 pounds pressure per square inch and must withstand a hydraulic pressure test of 1000 pounds per square inch. Consequently it is adaptable to all ordinary conditions of service.

Three types of pipe are used, the bell and spigot, bell and thread and the spigot and spigot or double beaded pipe. This latter type has been developed by Mr. George Read, Superintendent of the Meter and Service Department, of the Los Angeles Bureau of Water Works.

Tappings are made on the side of the main at midsection of the pipe. The standard depth of the street main as laid in Los Angles is 30 inches from the top of the pipe to the finished grade of the street so this makes the cover over the service pipe in excess of 30 inches.

The method of connecting up the 2-inch cast iron service pipe is as follows: The piece entering the curb is equipped with a standard 2-inch pipe thread. The inside diameter of the pipe at the thread end is slightly reduced in the internal diameter to compensate for weakening at the thread. From the curb piece to the main, bell and spigot pieces are used. The fill-in piece between the bronze corporation cock and the bell and spigot piece is made with a piece of double beaded 2-inch cast iron pipe to prevent slipping. This double beaded pipe is of standard 5-foot length with a single bead on each end and double beads spaced $7\frac{1}{2}$ inches apart. The pipe is cut between the double beads which gives closely the length required, and adjustment is made inside of the curb.

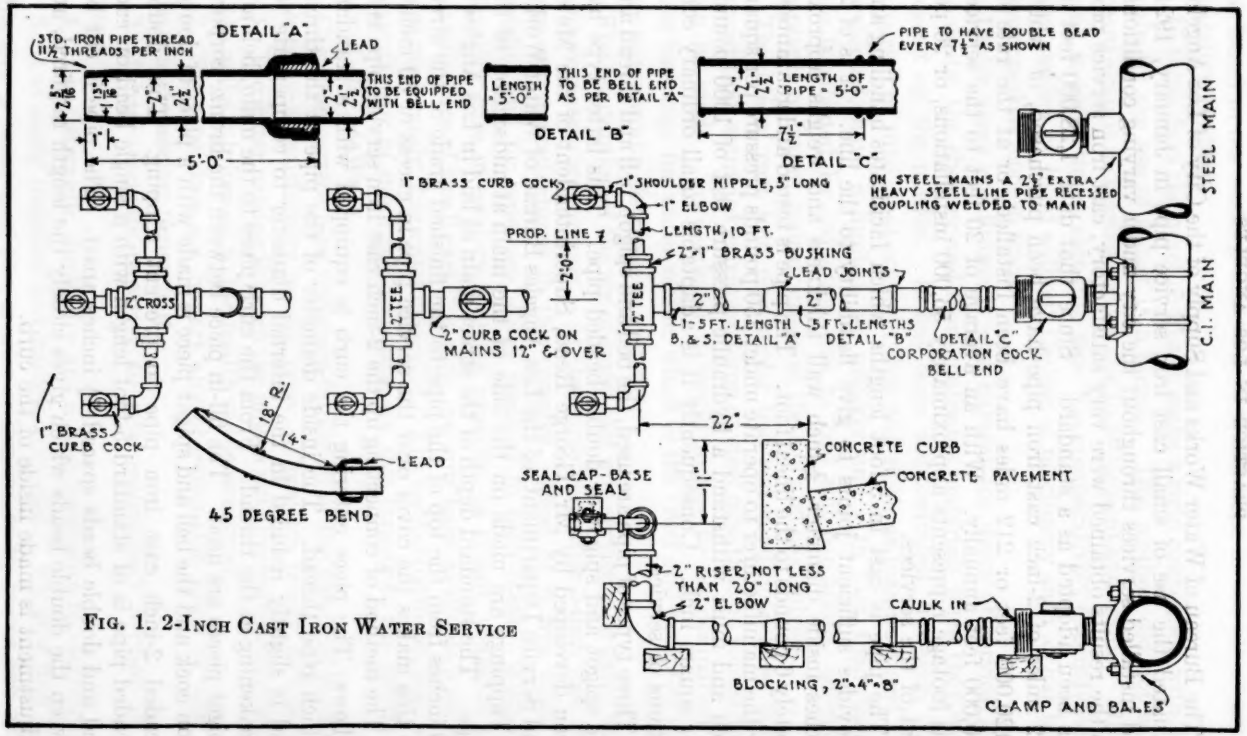

FIG. 1. 2-INCH CAST IRON WATER SERVICE

The bronze corporation cock has a bell end to take the 2-inch cast iron pipe and a 2½-inch iron pipe thread to screw into the saddle on the main. The threaded piece entering the curb is equipped with an extra heavy galvanized iron 90 degree elbow and an extra heavy galvanized iron riser on the top of which is screwed a 2-inch extra heavy galvanized iron tee, which is fitted with bronze bushings according to the sizes of the services required. Each joint of the pipe when it is not bedded on the bottom of the trench is supported on blocks placed under the bell to insure perfect alignment, support the pipe and prevent settlement while being puddled and backfilled. The end of the service pipe inside the curb is also blocked back of the ell.

This installation provides for two ¾-inch, two 1-inch and two 1½-inch services. The ¾-inch services may be enlarged in the future if desired to a 1-inch and a 1½-inch or a single 2-inch service. The necessity of enlarging services due to the change of use of property is an important item, especially in our growing cities. With services up to a 2-inch this may be accomplished at a small cost and without digging into the street.

The 2-inch service pipe is installed 2 feet off of the property line and the connections inside the curb are set 8 and 12 feet respectively along the curb from the 2-inch pipe. This makes the location of the meters 10 feet inside the property lines. The location of the 2-inch service pipe does not conflict with the placement of poles or fire hydrants and the meter location does not interfere with private driveways. By the use of 2-inch cast iron pipe from the main to the curb for the supply of small services, appreciable friction loss through the small service pipes is eliminated, especially where the service crosses the street.

Lead joints are used exclusively and are of three types, the "prepared or precaulked joint," furnished with the pipe by the manufacturer; pure lead strips, 2 required to the joint, each strip is $\frac{3}{16}$ inch thick, 1¼ inches wide and 7.85 inches long; and the poured joint made by standard practice.

All three methods of making the joints have been given a thorough test by the Los Angeles Bureau of Water Works and Supply. Its experience is that the most satisfactory results are obtained from the old reliable bell and spigot poured lead joint on the job. In point of time it takes no longer to make this joint than to assemble the others. Furthermore, you are assured of the bell being completely filled, which condition is essential for a perfect joint.

The lead is heated by a special gas furnace in a 40 pound capacity melting pot and requires about 8 minutes to melt the batch ready to pour. About $1\frac{1}{8}$ pounds of lead are required per joint.

The proper length for each service is obtained and the material assembled. In most cases the joints are poured in a vertical position from the service truck. By this method up to 5 lengths are joined together, as a single unit. The spigot end is entered into the bell and dry sand poured in to center the pipe, then the lead is poured from a small ladel, the pipe is lifted vertically and put through the same operation until the desired number of joints are made. Two men accomplish this work and each joint is completed in not to exceed a minute. The section is then laid on the ground and caulked. The assembled pipe is then picked up and carried to the trench, lowered and the joint with the bell corporation cock at the main is made. The pouring of this joint differs from the standard method for cast iron pipe, although oakum is used. But in place of a clay collar, the shoulder for running the joint is made from a piece of oil treated gate packing about two feet long which is wrapped around the pipe twice at the face of the bell and held with a wire staple, this method is simple and fast. Where it is necessary to make the joints in the trench due to other substructure interference, this same method is employed. By the use of an augur, openings are made under railway tracks, or other structures, and the service is assembled in the trench and pushed ahead. Where interference in alignment is encountered, the bell and spigot double beaded 45 degree ell 15 inches long is used to advantage, allowing the flexibility necessary for going around, under or over obstructions encountered. The ell is cut at the double bead and provides a $22\frac{1}{2}$ degree swing. With this combination it is found that cast iron services may be laid under the most complicated conditions, with no more trouble or expense than is involved in the installation of other types of service pipe.

In addition to the small cast iron service, 3, 4, 6 and 8-inch cast iron services are standard installations in our system and have been in general use for more than twenty years.

DISCUSSION

WILLIAM LUSCOMBE (Gary, Ind.): I should like to ask Mr. Hurlbut the smallest size he recommends using in cast iron.

MR. HURLBUT: From $1\frac{3}{4}$ to $1\frac{1}{2}$ inch, up to 2 inches.

MR. LUSCOMBE: Will you kindly state what are the advantages in using cast iron pipe in the smaller size, say, inch and a quarter, over using copper or brass of the proper strength and weight?

MR. HURLBUT: In our city we do not use the small cast iron pipe. The value would be this, primarily, as far as our experience is concerned: that the life of the pipe is longer, due to the fact that the oxidation which takes place on the average galvanized pipe, or steel pipe, is much more rapid, that on the cast iron pipe. We have never used lead services. We do use copper pipe at the present time, but where we have to make only individual installations.

MR. LUSCOMBE: What kind of material do you find most practical to use for the smaller services, like the $\frac{3}{4}$ and 1-inch sizes?

MR. HURLBUT: We lay nothing but 2-inch pipes, and then run the pipe inside the curb, making the 2 or 3 service connections on it. We use nothing smaller than 2 inches any more, except the 1-inch copper service. In exceptionally high territory in the hills we do lay an extra heavy galvanized steel pipe. That is where we have pressure in excess of 250 pounds to the square inch. Services are necessarily few and far between as yet. We are not in position to regulate the pressures due to the rapid development. There has been irregular development of the country in the hill section.

W. A. KUNIGK (Tacoma, Wash.): In Tacoma we are using galvanized steel pipe for all services, with pressures from 40 to 175 pounds in our distribution system. I should like to ask Mr. Hurlbut how your lead joint would work out for the heavier pressure services. Would there not be danger of pulling apart, especially where you have to put in a number?

MR. HURLBUT: We have had no trouble with it. We have cast iron services on regular pressures under 225 pounds, and we have had no difficulty. The pipe is not a plain-end pipe; it is a beaded pipe. You really have a durable layer in that respect on the joint when it begins to pull.

C. NEWELL (Provo, Utah): I should like to ask what charge is made for these services.

MR. HURLBUT: Our standing charge for service in the City is $15 for the ¾-inch; $18 for 1-inch; and above that, $25 for 1½-inches. That is a service installation charge. Above that, services are put in on the time and material cost basis.

MR. NEWELL: Do you divide the larger services up?

MR. HURLBUT: The property-owner in all cases pays for the installation. That is a fixed service charge in Los Angeles. That rate includes the setting of the meter.

CHAIRMAN MACDONALD: From that statement of yours, Mr. Hurlbut, I would presume that your Department does not differentiate in the cost of a shorter service?

MR. HURLBUT: No, we do not. There is a fixed charge for each side of the service; and it is an equalized charge on both the long and short side of the street.

L. MURRAY GRANT (Seattle, Wash.): I should like to ask Mr. Hurlbut if they make it a practice, in improving the streets by adding water mains, of putting in service blinds, and having them at the curb for future use; or do you place these services as they are needed?

MR. HURLBUT: All service installations are put in ahead of all permanent paved streets, inside the curb, and plugged at that point. Wherever application is made, we take off on that 2-inch connection at that point, up to the 2 inches. In all cases, services have been installed in permanently paved streets.

L. MURRAY GRANT: These are aligned to your curb cock?

MR. HURLBUT: Yes.

MR. GRANT: You have no trouble there from the water taste due to dead ends?

MR. HURLBUT: We naturally blow those surfaces off before we set the meter.

MR. GRANT: Of course.

MR. HURLBUT: No, we have no trouble.

PRESIDENT GIBSON: Mr. Chairman, I'd like to ask Mr. Hurlbut when he collects this charge for the service? At the time of installation?

MR. HURLBUT: At the time of installing.

PRESIDENT GIBSON: So that the Department collects on all improved property, improved streets, as the street is paved?

MR. HURLBUT: Yes, that is done at the present time by collecting directly from the subdivider, in case of permanent paving.

PRESIDENT GIBSON: I want to call to the attention of you western gentlemen, in particular, that you have been able to pioneer along these lines. In the east we are bound down by a lot of tradition and laws that have been handed down from father to son, even before the Constitution of the United States was adopted—laws from which we cannot get away.

In South Carolina we cannot do these things. The law says we cannot compel the property-owner to do anything until he gets ready to do it. While we have tried to anticipate conditions, we have never yet, so far, been able to guess exactly what the property-owner is going to do, even three months after the street is paved in front of his property. We have laid services and we find when we come to use it that the property-owner does not want it where we have laid it. He can insist upon another service, and we have to give it to him. We cannot make him pay for the service already laid. In fact, we are pretty nearly at the mercy of the property-owner at the time he wants a service.

MR. HURLBUT: There is another point in connection with your question that I will clear up. In the case of paving a street, in what you might call the older portion of the city, which is largely built up, but where there are a few vacant lots whose owners we are not able to determine, we install those ahead and then assess the property, and collect when the time for improving that property

comes around. So there are hundreds of services installed annually. We clean up a street as we go through.

L. M. GRANT (Seattle, Wash.): Do you carry that as a suspended charge? When they ask for their service do they have to pay it?

MR. HURLBUT: Yes. Those are marked with assessed marks so nobody can have a meter set until he pays for that installation.

CHAIRMAL MACDONALD: I should like to ask in the 2-inch cast iron installation prior to new pavement, what is the minimum service charge to the fronting lots in the event of that service applying to two or three lots?

MR. HURLBUT: Exactly the same. That is, \$15 for the $\frac{3}{4}$-inch; \$18 for 1-inch; and \$25 for $1\frac{1}{2}$-inches. That is the service charge. Of course, a 2-inch line will supply two lots.

CHAIRMAN MACDONALD: My point was that at the time of installation the property might be vacant, and it might not be determined at that time what size service to put in.

MR. HURLBUT: In that case, the condition and the character of the improvement would necessarily determine the size of the service. For residential purposes we usually put in the 2-inch service, where they are mostly of the larger size; but the average service installation is $\frac{3}{4}$-inch for residences. Anything larger than 2 inches brings with it the question of cutting the pavement whenever a development of that kind comes along.

MR. LUSCOMBE: Mr. Hurlbut, have you any means of knowing about what percentage of the total number of taps are to be used on the service that you install ahead of paving improvement, say, within the first three or five years. It has been our experience that quite a number of such installations prove impractical, that the size and the location of the service stops seem installed just where they are not needed. Of course, there are points in favor of it and against it.

MR. HURLBUT: That is very true, but we do not find that over 5 per cent of the services installed must be changed. On that basis we are way ahead of cutting entirely new street pavement.

MR. KUNIGK: It was our practice to put in light services at the expense of the Water Department before the streets were paved. But, as a result, we had a good many thousand services on our hands which were not of the right size and which were useless to us. Subsequently we followed the practice of waiting until the streets were ready to be paved. By that time we sent notices to all the property owners in the street and notified them that pavement was to be put in and service would be installed at that time. At that time we get the right size from them and it has worked out very satisfactorily.

L. M. GRANT: I might say that Seattle has had exactly a similar experience. We have thousands of dollars tied up in blind services that probably will never be recovered. The services were made at that time of wrought iron, and some have been eaten off by electrolysis. To get at the leaks, in the aggregate you cut as much pavement as to put in new services where they are needed.

MR. HURLBUT: We had the same experience before we adopted the cast iron service. Even since, within the last five years, whenever we find a leak, we go down and cut off the two services at the main and install an individual 2-inch line of cast iron to take care of those two services. We have had no difficulty with the dead end cast iron service. Our experience is only five years at the present time on that. But so far, an examination of those lines shows that we have had no difficulty whatever.

PRESIDENT GIBSON: I take it that Mr. Hurlbut has no trouble with tuberculation with Los Angeles water.

MR. HURLBUT: We have not.

PRESIDENT GIBSON: The waters along the east coastal plains are usually colored, very soft, and contain large amounts of organic matter, tannic acid particularly. These waters produce tuberculation easily. I have had 2-inch mains, even 4-inch mains, practically stopped up in the course of ten or fifteen years. We have adopted, of course, as you probably all know from published papers of mine, cement lined pipe. We find this practice relieves the tuberculation.

We have not used any 2-inch cast iron service pipe. But we do use exclusively lead pipe for two reasons, it does not tuberculate and

it does not deteriorate from the outside. Of course, our soil is 6 or 8 feet above tide. It is a sandy soil, with a great deal of organic matter in it, because that is soil that has been built up by the vegetable growth and the erosion from far points. Wrought iron, galvanized or steel pipe would last perhaps eighteen months in a great deal of our territory. Therefore, we had to adopt lead service pipes from the main to the curb.

I have never tried any of the 2-inch pipes except for extensions in the newly developing territories in which I had no idea of what was going to develop. The 2-inch pipe there is cement lined, with the Simplex type of joint. Afterwards as the territory develops we replace that with a larger main and we recover a 2-inch pipe.

L. A. DAY (St. Louis, Mo.): Is there any provision made for any flexibility with the 2-inch pipe connected to the main.

MR. HURLBUT: The connections were made through a bell corporation cock, with a bell and spigot joint.

MR. DAY: Do you set two meters in a common box?

MR. HURLBUT: The meters are set 20 feet apart. The installation from the 2-inch line was 12 feet along the curb in one direction, the 2-inch line coming in 2 feet off the property line. So the meters are 20 feet apart.

MR. DAY: Is cast iron pipe carried to the meter?

MR. HURLBUT: It is simply carried inside the curb. From that point on it is 2-inch galvanized steel, extra heavy. Then we carry galvanized steel in $\frac{3}{4}$-inch or $1\frac{1}{2}$-inches. The standard there is the same as it used to be.

MR. LUSCOMBE: Where you install so many services ahead of street pavement, have you considered the comparative cost of a secondary main, putting in 2-inch services across.

MR. HURLBUT: The side lines are more expensive. If you are familiar with Los Angeles, it is a complicated system. If you have a side line, one on either side, you will find you run into excessive

cost; so we are not laying anything less than 6-inch pipe at the present time. It means getting back to a smaller pipe, in order to take care of your requirements.

W. F. GOBLE (Alhambra, Calif.): I should like to ask Mr. Hurlbut if he has used any galvanized wrought iron.

MR. HURLBUT: We have used a great deal of it. Our experience has always been good with wrought iron pipe. There are certain sections of the city where we have soil conditions that are not conducive to the longevity of that pipe. Of course, what I have mentioned in this paper is largely the experience of a comparatively short time. The rate at which the city is increasing in population, where installations are in excess of 20,000 annually, it is quite a problem from that standpoint.

S. B. MORRIS (Pasadena, Calif.): I want to say in passing that we regulate the size by ourselves, determining the size of the service which in our belief would be required for the various lots, and sending notice to the owners of the size we propose to put in. When proper legal notices are given, if they do not protest those sizes, they are installed. If they do protest them they are adjusted in accordance with their wishes. In that way, we install $\frac{3}{4}$-inch up to 6-inches. We follow in general the same practice as Los Angeles in laying a 2-inch service for two lots.

In the business district we install about every 50 feet, irrespective of the lot, because they are continuously changing. In open territory, in the residential areas, which may not be subdivided, we install 2-inch connections about 100 feet apart. If the lot is subdivided, we install a connection every 50 feet. If the lot is 250 feet or larger we install 2-inch connections for every 100 feet.

About the only difficulty with the joint services, in supplying two and sometimes three houses, from one 2-inch service, is the noise on the pipe. There are a few instances where the people occupying one house do not look after their plumbing. We get a lot of complaint from the people in the other house who are more sensitive, as they get it on their plumbing as well. That difficulty has not been as easily remedied as we should like. Some people do not object to the noise and will not make the repairs which they should to prevent the noise on the neighbor's pipes.

DEAD ENDS[1]

By S. B. Morris[2]

In order to find out what the policy of other water works corporations was and to learn what progress their executives had evolved for meeting the problem of dead ends, I wrote a note to eight of my friends in the water works fraternity. Their replies were unanimously opposed to the maintenance of dead ends wherever they could possibly be eliminated. Everyone provides a fire plug or blowoff to bleed the dead ends of mains unless an active service can be placed at the extreme end of the main.

Practice of blowing off these bleeders varies. Some blow them off at fixed intervals of two weeks to two or more months; others bleed them only upon complaint or at irregular intervals as experience dictates. When dead ends are caused by valves being closed between pressures one large city makes a practice of cracking these valves sufficiently to cause some circulation from the higher to the lower pressure.

Replies to my letter show that not all are agreed upon what the real source of difficulty is with the dead end mains or the sealed services which present somewhat the same problem. Mostly the trouble appears to be with the taste and odor of the water due to products of bacterial action. One city engineer attributes this taste to the pipe or the pipe dip; another engineer believes the corrosion due to gasses formed is the greater problem.

In the short time allotted to me I shall attempt to analyze briefly and weigh the several problems pertaining to dead ends in water mains and sealed services.

Dead ends affect the carrying capacity of the mains for general and fire purposes. The stagnant water in dead ends causes tastes and odors and may affect the rate of corrosion of the pipes. Different metals used in the manufacture of the various kinds of pipe affect the

[1] Presented before the Superintendents' Round Table Discussion, San Francisco Convention, June 11, 1928.

[2] Chief Engineer, Water Department, Pasadena, Calif.

water differently, and in turn the pipes themselves are affected differently by different qualities of water.

EFFECT ON HYDRAULIC CAPACITY AND RELIABILITY OF SERVICE

The undesirability of dead ends from the standpoint of main capacities for general and fire purposes is immediately evident. For the same sizes and lengths of pipe the dead end main will have not more than one-half the capacity of the circulating main and will be twice as subject to interruption or failure of service through being supplied from but one end. Water pressures will fluctuate more widely and water hammer is more severe in the dead end main. The circulating system tends to equalize pressures and drafts by spreading of the load factor.

EFFECT UPON QUALITY OF WATER

In discussing the effect of dead ends upon the quality of the water served to the consumers, it is well to consider just what chemical and bacteriological reactions take place. The average city water contains more or less dissolved oxygen, organic matter, acidity or alkalinity.

The dissolved oxygen is rapidly consumed either by bacterial action or oxidation of the interior surface of the pipe. Aerobic types of bacteria must then die off entirely unless they are able to form spores which could continue only as spores. Anaerobic bacteria, however, will thrive and their numbers at any moment will be determined by the available organic food supply present.

The activities of aerobic bacteria are not productive of such especially bad odors and tastes as the anaerobic. It is to this latter class of organisms that we must attribute the worst dead end conditions. Normal laboratory procedure is effective only for aerobic types of bacteria and these at the body temperature of 37°C. Anaerobic bacteria grow better at 20°C.

When bacteria consume organic matter in the presence of oxygen the reduction products which they form are not objectionable and possess neither taste nor odor. When bacteria work upon the same types of organic matter in the absence of the all important dissolved oxygen the decomposition products which they form are foul smelling. Such products as hydrogen sulphide and other highly odoriferous sulphur compounds are formed.

While none of these products which give to stagnant water its characteristic odor are at all dangerous to the health, they are at times the source of much complaint by the consumers and a disturbing problem to the water superintendent.

Probably most true dead ends have little or no circulation, though chemotaxis may play a part for we know that most bacteria will move toward available food. As the organic matter in the dead end becomes depleted, there may be some movement of the bacteria from the dead end toward the portion of the pipe where water is in motion and a fresh food supply is available. Such movement or circulation is not thought to be appreciable.

Tests made of active and sealed services from the end of the same 2-inch cast iron lateral show little or no apparent contamination of the active service.

I am much indebted to Mr. George Read, Superintendent of Meters and Services and to Dr. Carl Wilson, Director, Biological Laboratory for the Bureau of Water Works and Supply, Los Angeles, for many analyses of water from sealed services and able discussion of the biochemical problem. The results of these tests and other analyses conducted in our own laboratories at Pasadena show widely varying conditions from which some general statements may be made.

In any given dead end bacterial action will increase rapidly until oxygen and organic matter are consumed after which the bacterial action will rapidly diminish to a very low condition. Foul gasses will begin with the failure of the oxygen supply soon reaching an optimum after which they will cease to be produced with the lessening bacterial action. Tests by Dr. Wilson indicate lesser bacterial action in sealed copper services than in sealed cast iron services, which may be due to germicidal action of the copper, although insufficient tests have been made to be conclusive.

Therefore, we cannot expect any certain fixed time of flushing such, as every two weeks, every month or any other inflexible period to be proper for every water system, nor for every dead end in the same system. In fact, in almost every system the quantities of oxygen, carbon dioxide and of organic matter are so variable with the season and with the several sources of supply that only experience in the individual case can be used as a safe criterion. We are quite safe in saying that a very old dead end which has not been flushed will no longer require any flushing as bacterial action has practically ceased and the obnoxious gasses are no longer produced.

EFFECT UPON CORROSION

There appears to be a general opinion that dead ends or sealed services are much more rapidly affected by interior corrosion than pipes through which water is constantly moving. A theoretical discussion of the active elements of corrosion, and observation of many sealed services in comparison with active services does not appear to sustain this opinion.

The most active corrosive elements in the average city water supply are: dissolved oxygen, which we have seen is rapidly used up and does not replace itself; free carbon dioxide or carbonic acid, which may not in itself be used up, but which cannot continue to be active or effective without oxygen, and hydrogen-ion concentration. Hydrogen-ion concentrations represented by values of pH greater than 10 are only slowly corrosive, between pH 4.3 to 10 moderately, and less than a pH of 4.3 rapidly corrosive. Here again oxygen must be present to break the polarizing film of neutral hydrogen atoms on the metal to complete the corrosive action under the electrochemical theory of corrosion.

We have not time here to go more fully into the detailed theories of corrosion and the effect upon the several metals now used for mains and service piping. Inspection of services in our Pasadena system, varying from ten to forty-one years of age, in both sealed and active condition appears to substantiate the fact that interior corrosion is not more rapid for the sealed service than for the active service and may be materially less, due to the absence of dissolved oxygen.

It would appear that frequent flushing of dead end mains may materially add to the rate of interior corrosion over that to be expected if the mains were not flushed. The optimum rate of dissolved oxygen and carbon dioxide for maximum corrosion may be brought about for a greater percentage of the time through such flushing than if the dead ends were allowed to reach their inactive condition through complete consumption of oxygen and other corrosive elements.

ELECTROLYSIS

Dead end mains and services are naturally more subject to electrolytic action from stray street railway currents. If such dead end pipes or services are positive to the earth in the direction of their dead ends, currents will flow from them into the soil, thus concentrating corrosive action near the ends of such pipes.

CONCLUSIONS

From the above discussion we must conclude that dead ends are something we should restrict to an absolute minimum in any modern water works distributing system, for such dead ends tend to decrease pressures, lessen fire flows, increase shutdowns, increase water hammer, increase complaints of tastes and odors, and in some cases they may increase corrosion, particularly from electrolysis. The growing use of duplicate mains on each side of a street should make the number of dead ends between pressure districts less necessary. In fact this is an additional argument for such duplicate mains.

The practice of locating fire plugs on dead ends as effective bleeders for the mains is desirable in flushing the pipe lines, but not so satisfactory from the standpoint of fire protection.

Cracking of valves between pressures to give a slow circulation from the higher pressures to lower ones is a hazardous procedure as far as the valve is concerned. A better procedure where such circulation is necessary, would be to install small bypass valves for this purpose.

For average water conditions sealed services should present no greater problem than active services. Where severe conditions are known to exist, sealed services can be installed with the corporation cock at the main closed, and a valve box installed over such cock so that the service can be turned on when required. In this way water in not turned into the services until it is to become an active service. This is the present practice in some cities.

In this brief discussion, which is already much longer than I had planned, I hope I have touched upon some of the problems of dead ends which I believe deserve more careful consideration than has generally been given the subject. Perhaps the words may find their proper place, at least in the index of the next edition of "Water Works Practice."

DISCUSSION

Wm. W. Brush:[3] I wish to call attention to the question of the pH as affecting the rate at which corrosion takes place. If I remember correctly, Mr. Morris said that a pH of about 4.5 permitted moderate corrosion. We find that 6.7 produces active corrosion sometimes.

[3] President, The American Water Works Association; Chief Engineer, Department of Water Supply, Gas and Electricity, New York. N. Y.

We are now carrying on some extensive experiments and we have spent as much as $500 a day to treat temporarily the Catskill water to bring the pH up to about 8.4, but it is not stopping corrosion altogether.

It is understood quite generally that standing water will accelerate corrosion. There is no reason why standing should produce corrosion any more than if the water were moving, for the oxygen will be used up very rapidly and cause oxidation, and the iron will be protected from corrosion by the coating.

We find in our experiments with a service pipe that, where the water is changed about once in twenty-four hours, the oxygen is completely exhausted at that time. No doubt in less than the course of a year I shall be able to tell you a great deal about the subject respecting the individual water used.

As Mr. Morris has pointed out, you must find out the condition that exists in your particular locality. It is not advisable to blow off more quickly than necessary. We blow off dead ends at different periods, depending upon the locality and upon the type of water used in that locality.

We find, as Mr. Morris says, that unless we blow at certain intervals at almost every point where the dead ends are the accumulation of iron oxide will result or else we will have disagreeably tasting water on account of the bacterial action which takes place. Therefore, it is necessary generally to blow off practically all the dead ends at some interval.

CHAIRMAN MACDONALD:[4] I should like to ask Mr. Brush if in the residential section he has adopted the policy of using a duplicate main to any extent?

WM. W. BRUSH:[3] We are using duplicate mains only where we have a width of street of 80 to 100 feet. Our usual city street is 60 feet, with 15 feet for sidewalk and 30 feet for roadway. I find that my Commission is disinclined to approve of duplicate mains, unless there is a trolley in the center on a street approximately 100 feet in width.

It seems to me that the general tendency would be to lay two mains in streets of 80 to 100 feet or greater in width. That practise will be quite beneficial at times in eliminating dead ends, but

[4] City Water Works Engineer, Ottawa, Can.

not altogether, because dead ends are caused first by shutting the valves and second, by extensions which are not carried to a connecting main because the buildings do not justify that length of main. That is perhaps where we have most complaint, because in a boundary district we usually have buildings erected on both sides.

S. B. MORRIS:[2] It occurs to me if properly planned there is no reason why the duplicate main method should not carry off dead ends which are necessary between pressure districts. In fact, I think that would be one of their primary purposes. I know we have made use of them in that way in our own system. Where we have two mains in the street, where the pressure is divided in the middle of the street, these circulating lines were run on each side and eliminated the dead ends of that system.

CROSS CONNECTIONS—THE HEALTH HAZARD VS. THE FIRE HAZARD[1]

By Charles W. Sherman[2]

In recent years many articles have been published in engineering periodicals and water works journals on the subject of "cross connections." Moreover, several organizations have appointed committees for the purpose of investigating the same subject. Within the past three years resolutions in regard to cross connections have been adopted by the fire protection division of the American Water Works Association and by the Conference of State Sanitary Engineers. On March 14, 1928, the Committee on Cross Connections, New England Water Works Association, submitted a report to the association, and from this report most of the material for the present paper has been taken.

DEFINITION

By a "cross connection" is meant a connection between the distribution system of a public or private, potable water supply and a private or secondary, non-potable supply.

The common example is a connection between the public water supply of a municipality and the auxiliary fire hydrant or sprinkler supply of a mill or factory,—the former sufficing for ordinary uses, and the latter for fire fighting only. However, cases occur in which the public supply is used for drinking, toilets and lavatories only,—water for all other purposes being from the secondary industrial supply. In other cases, water for various industrial processes, including boiler feed water, as well as water for drinking, toilets and lavatories, is taken from the municipal source, leaving the industrial source for private fire supply and miscellaneous industrial uses.

Connections are usually made through piping and gate valves, with or without accompanying check valves. Check valves vary in type from a single iron check valve, with a swinging clapper, operat-

[1] Presented before the New York Section meeting, May 4, 1928.

[2] Consulting Engineer, Metcalf & Eddy, Boston, Mass.

ing against an unfinished iron seat, to the double, bronze, check valves, devised by the Associated Factory Mutual Fire Insurance Companies. The former are not precisely machined to prevent leakage, are usually inaccessibly located because buried in the ground, and are so liable to rust that the free movement of the clappers is obstructed. The latter are of excellent workmanship, are usually set in vaults, or where they are accessible for inspection at all times, and are built of rustless bronze with rubber-on-bronze seats. Gaging and testing cocks accompany this type of valve.

THE DEMAND FOR CROSS CONNECTIONS

The principal demand for cross connections comes from fire insurance companies and from property owners who desire two rather than one source of water supply for additional protection to life and property. Opposition to cross connections has come principally from the health and water works authorities, largely because numerous epidemics have been due to these connections.

INDUSTRIAL USE

Many large industrial plants and public utility companies require a constant supply of water for boiler feed, for cooling purposes, and for various manufacturing processes. To insure continuous operation, some secondary stand-by supply must often be available.

It is usually prohibitive in cost to purchase public water for such uses and at the same time store a supply of potable water sufficiently large for probable emergencies. Some way of using either supply when needed is a practical necessity.

FIRE PROTECTION

The automatic sprinkler has made it possible to concentrate enormous values with safety in industrial plants, mercantile buildings and warehouses. A good public water system is the best primary supply for automatic sprinklers, and there is usually no practicable way of providing an alternative primary supply which is equivalent to it. Even large elevated tanks, involving great expense, are necessarily of limited pressure and capacity. But municipal water supplies *alone* cannot be depended upon in all cases, for two reasons:

1. Fire will not wait in case the public water supply should happen to be out of service. Consequently, if the advantages of automatic sprinklers in

extinguishing fires *at the start* are to be realized, there must be pressure *always* on the sprinklers.

The Associated Factory Mutual Fire Insurance Companies have recorded about three hundred instances in which public water supplies have failed or been interrupted. In twelve of these instances fire broke out simultaneously with the interruption of the water supply.

2. Public water supplies are frequently *inadequate* in volume and pressure for the large number of automatic sprinklers and hose streams which might be needed to cope with a serious fire.

Therefore, whenever the value protected, or the fire or life hazard involved is sufficiently great, a secondary supply is needed in order that automatic sprinklers may be able to control a fire at the start. The Labor Laws of New York State permit double the number of employees in a building equipped with a sprinkler system.

It is usually impracticable at reasonable cost to provide a secondary supply of sufficient capacity to assure a volume of water adequate for an emergency, such as an unusually severe fire or a conflagration, and of such quality as to be considered potable. Secondary supplies are usually obtained by utilizing open bodies of water such as ponds or rivers. A cross connection is the only practicable method at present available, of combining the existing potable public water systems and the available non-potable secondary supplies of large capacity, both automatically feeding into a common fire protective system, capable of meeting the demands of sprinklers and hydrants during the progress of the fire. Such a cross connection, in order to function instantly when fire occurs, cannot be dependent upon manual operation, but must be automatic.

CROSS CONNECTIONS AND PUBLIC HEALTH

The Committee's report refers to 25 instances where outbreaks of disease have been brought about by pollution of drinking water supplies through cross connections. In nineteen of these instances, the cross connection contained only a single gate or check valve. In three instances, some protection against mixing of unsafe with safe water was afforded by two gate valves or by a check valve and a gate in series, and in one instance, there were two gate valves and a check valve in series on the cross connection. In one instance, it might be assumed from the wording of the published record that protection against pollution was afforded by two gate valves and a double check valve arranged in series, although this was not definitely stated. In another case this condition was definitely stated. One

of the double check valves which failed was of inferior type and one had not been inspected recently.

Epidemics due to cross connections. A few details of typical examples of epidemics caused by polluted water entering drinking water systems through cross connections are given below.

An outbreak of illness characterized by very severe diarrhea of sudden onset, accompanied by fever, occurred in Poplar, England.[3] Nervous symptoms manifested by convulsions or fits preceded the attacks in some cases. Generally speaking, the symptoms were very alarming at the onset but subsided in twenty-four hours, leaving the patients weak. The cases occurred in a relatively small area. Records of the analyses of samples of tap water examined by the Metropolitan Water Board of London indicated that locally the tap water was of an inferior quality. Further investigation disclosed the presence of a cross connection of a private water supply of a gas plant and the public mains. No check valves were used on this cross connection.

At Albany, New York,[4] in October, 1927, an epidemic of diarrhea, followed by 30 cases of typhoid, was caused by polluted water from an industrial supply leaking into the city mains. There were three cross connections, each of which was guarded by one or two gate valves. The pressure of the industrial supply was in excess of the city pressure.

At Rockaway, N. J.,[5] in May, 1923, the single check valve on a cross connection between a fire supply and the municipal supply was stuck open and so encrusted with dirt and rust that the flap could only be moved by the use of a bar." The fire supply was polluted by the effluent from a septic tank receiving excretions of a typhoid carrier. A temporary reduction in pressure on the public supply caused the fire supply to flow into the town mains, with the result that there were 41 cases and 4 deaths from typhoid.

At Franklin Furnace, N. J.,[6] an open gate valve and a leaky check valve on a cross connection between municipal and industrial supplies at the New Jersey Zinc Co. late in 1922 allowed polluted water to enter the town water supply, causing 114 cases and 18 deaths from

[3] Bulletin of Hygiene, Vol. 2, No. 12, p. 982, December, 1927.

[4] Health News (N. Y. State Dept. of Health), November 21, 1927.

[5] E. N. R., Vol. 91: No. 7, p. 267, Aug. 16, 1923.

[6] E. N. R., Vol. 89: No. 24, p. 1045, Dec. 14, 1922: E. N. R., Vol. 91: No. 11, p. 429, Sept. 13, 1923.

typhoid. A recent underwriter's test of the fire protection system had put a heavy extra pressure upon the check valve.

Forty-two cases of typhoid were caused at Cohoes, N. Y.,[7] in 1927, by pollution of the city supply by Mohawk River water, which entered through a cross connection with an industrial supply. Just prior to the outbreak, two gate valves in series on the connection were operated once, and the city pressure was low at five different times.

At Oswego, N. Y.,[7] in October, 1927, many cases of diarrhea and 9 cases of typhoid in a factory were traced to the pollution of drinking water through a cross connection with an industrial supply. The cross connection was protected by two globe valves and two check valves in series, probably of an old type.

It may be noted that none of these epidemics resulted from contamination passing through cross connections guarded by a modern installation of double check valves.

Position of the public health authorities. While from the broad economic standpoint it may be undesirable to run the risk of fire losses and, possibly, some losses of life by accident to firemen and industrial employees, to avoid the other hazard of sickness and death due to the effect of cross connections, the saving of life rather than of money must always be the dominant motive for sanitary authorities. The following may be given as examples of the reactions of sanitary authorities to this danger.

The position of New Hampshire is as follows:

> Although recognizing that the ideal situation is one involving no connection whatsoever between a public water supply and a polluted industrial source, yet, with us it is a case of doing the best thing possible in view of existent facts. While admitting that no such device affords an infallible means of protection, yet it also cannot be denied that no form of protective action against a polluted water supply can be said to be infallible, these depending, as all of them largely must, upon the human factor.
>
> Accordingly, it is the present policy of the New Hampshire Board of Health to permit, for the purpose of fire protection only, of the use, in lieu of mechanical severance, of a suitable connecting device of the best approved type, providing also that such be installed in a proper test pit, and maintained under periodic inspection.

In December, 1926, the Rhode Island State Board of Health, while without authority to prevent cross connections adopted a resolution advising that all such be abolished.

[7] Health News (N. Y. State Dept. Health), Nov. 21, 1927.

In its bulletin of January, 1927, the Connecticut State Department of Health published an article by the Director of its Bureau of Sanitary Engineering. In this article, the author cites the regulations of the department, namely, that after December 31, 1926, no cross connections shall exist between potable and non-potable supplies, except that installations protected by double-check valves of approved type with adequate facilities for testing which were in existence on December 31, 1926, may be temporarily continued, with the approval of the State Department of Health. The latter provision was inserted because it was felt that double-check valves of the latest approved type should be given a fair trial. The length of the extension of time granted will depend upon investigations which the department is now making as to the efficiency of the newest types of valves. No new cross connections are allowed, even though protected by double check valves.

In New York State[8] the Public Health Council of the State Department of Health adopted an amendment to its sanitary code, which became effective on July 1, 1926, prohibiting cross connections between non-potable and potable water supplies after that date. This regulation permitted the continuance of cross connections where two gate valves with indicator posts and two check valves of the special design of the Factory Mutual Fire Insurance Companies or equal were installed, but such connections were to be discontinued after July 1, 1928. The regulation also permitted the use of dual water supply systems where the auxiliary supply was delivered to an elevated tank, provided the tank were open to atmospheric pressure and the potable water supply were discharged at an elevation above the high water line of the tank. Recently this regulation has been upheld, in the face of an attempt to have it rescinded.

In New Jersey,[8] a new chapter to the sanitary code was submitted

[8] Since the preparation of this paper the policies of New York and New Jersey have been modified somewhat. In New York the Commissioner of Health has ruled, as a result of the development of a special fire pump chlorinator, that the installation and proper maintenance of such a chlorinator would satisfactorily meet the requirements of the sanitary code. Certain conditions must be met prior to the approval of the department for such cross connections. Among these conditions is one calling for the proper installation of all bronze double check valves between the fire supply system and the municipal system. In New Jersey the state department of health has added a new chapter to the Sanitary Code which permits cross-connections through approved types of all bronze double check valves.

to the State Department of Health on April 21, 1927, by the chief of the Bureau of Engineering. This chapter would prevent any cross connections, by-pass valve or auxiliary intake, or other similar device which may permit any flow of water into an approved public potable water supply from any other supply of water, ... unapproved by the State Department of Health or not treated in accordance with these regulations. It permits physical connections with another approved public potable supply and with approved private potable supplies, "regularly examined as to purity by those in charge of the approved potable public water supply with which the connection is to be made and also regularly examined by the State Department of Health, provided there shall be no connection between the approved private potable water supply and water supplied from a source polluted or subject to pollution."

This recommendation was made on June 28, 1927, and would have become effective immediately, except that the time of discontinuance of connections could be extended to January 1, 1928, where the connection between an approved public supply and any other water supply included double-check valves of the Factory Mutual type, installed as specified by the State Department of Health in New Jersey. It is reported that this time has recently been extended, but the author has no information as to the new time-limit.

The Manufacturers' Association of New Jersey has requested an amendment to the new chapter which would permit permanent cross connections through double-check valves, provided that at least quarterly tests for tightness and annual internal examinations and cleaning be made jointly by accredited representatives of the owner and of the municipality, and that the results of these tests and inspections be reported to the State Department of Health. "The demand for this proviso," it is stated in the report, "demonstrates that such an installation is not absolute protection."

The General Code of the State of Ohio, section 1252–3, provides that "it shall be unlawful for any official, officer, or employee having in charge or being employed in the maintenance and operation of a public water supply and water works system or for any other person, firm or corporation to establish or permit to be established any connection whereby a private, auxiliary or emergency water supply other than the regular public water supply may enter the supply or distributing system, unless such private, auxiliary or emergency water supply, and the method of connection and use of such supply shall have been approved by the State Department of Health."

Other states have made similar regulations, but the above will suffice for illustration.

Action of the American Water Works Association. The fire protection division of the American Water Works Association adopted the following resolutions at Louisville, Kentucky, May, 1925.

Whereas cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water borne diseases, and

Whereas, check valves and other similar protective devices cannot always be depended upon, be it

Resolved, that no physical connection should be permitted between a potable public water supply and any other supply except as follows:

1. With another potable public supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

This prohibition to apply to all piping systems either inside or outside of any building or buildings, and

Be it further resolved, that definite programs should be inaugurated in each municipality to permanently eliminate all other connections.

Action of the Conference of State Sanitary Engineers. Similar resolutions were adopted in 1926 by the Conference of State Sanitary Engineers. A special committee of the conference presented a tabulation of outbreaks of typhoid fever and in some instances of enteric diseases caused by cross connections, auxiliary intakes and by-passes. This tabulation includes a total of 8,028 cases of typhoid fever with 226 deaths and also more than 11,000 cases of enteric disturbances.

The report of the committee to the conference contained the results of a questionnaire, summarizing the procedure for elimination of cross connections. As an example of what may be done, the experience at Chicago may be cited. A survey disclosed 428 cross connections, of which 179 were direct and 249 indirect. By the end of 1925, 85.3 per cent of these connections had been removed.

Legal liability. The legal cases which are cited in the report of the state sanitary engineers, support the position that municipalities, which through their officers permit cross connections with polluted supplies, become legally responsible for any epidemics resulting therefrom. In the opinion of the committee they become legally liable if the epidemics result from any negligence in the design, installation, operation or inspection of said connections. It is also true that equal if not greater responsibility rests upon state authorities regarding cross connections even though moral rather than legal.

RELATIVE HAZARDS

There is a tendency in some quarters to minimize the effect on sanitary quality of a water supply which certain hazards other than cross connections may produce. This is illustrated by one of the conclusions contained in the report of Committee on Water Supplies, presented to the Public Health Engineering Section of the American Public Health Association on October 20, 1927, from which the following is quoted:

> What to do with recreation on watersheds is a most imminent problem. The most pressing phase is the swimming problem in water supply streams, entertainment on a large scale, and hunting and fishing. . . . . Swimming should be considered more for its uncleanly effects on the stream. As a course of dangerous pollution it is of little importance.

It certainly is open to serious question for a municipality or state to prohibit all cross connections and yet allow swimming and boating on water supply streams. A typhoid carrier among the bathers might start a serious epidemic through the medium of the water supply. The writer absolutely disagrees with the last sentence quoted.

Other conditions which may be considered more hazardous than the existence of well-protected cross connections are: (1) an intake or main from a relatively unpolluted source passing through sewage-polluted water, and (2) a supply drawn from a polluted source and treated with chlorine, without provision for duplicate apparatus.

In considering the relative hazards of prohibiting and permitting cross connections, the following comparison may be made. In the 296 cases of interruption or failure of public water supplies, recorded by the Associated Factory Mutual Fire Insurance Companies, there were 12 cases where fires occurred simultaneously. In the 8,028 cases of typhoid and over 11,000 cases of enteric disturbance, resulting in 226 deaths, the losses by death and disability reached millions of dollars. Most of the deaths followed pollution through single valves or checks.

Obviously any single valve is too precarious a barrier between a potable and a polluted source of supply, and even the best installation of double check valves may fail for lack of proper maintenance.

Importance of inspection. Where the best double check valves are inspected frequently and thoroughly overhauled annually, the danger due to cross connections is reduced to a minimum. The permissibil-

ity of the best installation, other things being equal, therefore, hinges upon the frequency and kind of inspection.

Results of inspection of 1,032 sets of double check valves by the Associated Factory Mutual Fire Insurance Companies showed only 4 cases where both valves were leaky, and in these four leakage was slight and due to lack of care. An instance has been cited,[9] however, where both clappers of a double check valve installation were held partly open by a pair of overalls, thus again emphasizing the necessity for frequent inspection. The present standard arrangement of such checks requires that they be so far apart that it would be very unlikely that any single object could affect both checks.

Data regarding cross connections in New Bedford, Mass. are of interest. Here the check valves are inspected at least twice a year and the results show both valves leaky in 2 out of 2,152 tests, or less than 1 case in 1,000 inspections. None of the installations are of the latest type and many are quite old.

Immediately after the serious fire at Fall River, Mass., on February 2 and 3, 1928, the State Department of Public Health made tests of the cross connections by means of which the mill water supplies had been used to augment the city supply in fighting the fire. The mill supplies are drawn from the Quequechan River, which is highly polluted, and each cross connection is protected by a set of double check valves. Tests showed no evidence of leakage past the check valves or contamination of the city water at any of the five cross connections which were used during the fire.

The results of the first year of periodical testing by the State Department of Health of double check valves in Connecticut show that out of 624 tests on iron body check valves, there were 24 cases where one leaky valve was found and 1 case where both valves were found to be leaky because of uneveness in the flat, rubber seat facings. Of 273 tests of the all bronze valves, leaky valves (outside only) were found in 3 cases and in no case were both valves leaky.

In view of the large number of cases of sickness and resulting deaths, it is obvious that, if cross connections exist, they must be kept in dependable condition; the neglect of even the best device is dangerous. No pains should be spared to make inspections thorough. It is difficult to establish a procedure which will prove effective for all conditions, all types of installation and all places. However, it is believed that good results may be obtained by quarterly inspections

[9] Jour. N. E. W. W. Assoc., Vol. 36, p. 406.

with immediate repair or adjustment of any device not found in perfect condition. Where possible, inspections should be made through the coöperative efforts of both state and municipal authorities on the one hand and the mill owners and insurance companies on the other. Installations in each municipality should be examined by a state official at least once a year.

The attention of water departments is called to the frequency of unknown and unprotected connections, not only as regards their existence, but also as regards type and condition. Poor conditions are more prevalent in the case of the old installations. These connections should be abolished or protected.

The coöperation of the insurance companies is exemplified by the action of the Associated Factory Mutual Companies, which are chiefly interested in the protection of factories and mills, as contrasted with general fire protection. These companies at their executive meeting on December 12, 1927, adopted the following procedure.

a. See that every set of double check valves, both old and new, receives the necessary supervision. Experience has shown that many risks do not appreciate the importance of keeping the double check valves clean and tight by means of an annual overhauling. Our work would be in the line of education and assistance.

b. Pending the decision in each case as to the final outcome, see at once that every single check valve between potable and non-potable supplies is made accessible and kept tight as is being done in the State of Massachusetts.

c. Make a study of fire service connections at our plants both insured or prospective, and determine where it would be wiser to eliminate cross connections and where best to provide other supplies. Then for those risks where cross connections should be retained, have all-bronze double check valves put in and provide for periodic and effective supervision of them as outlined in paragraph *a* above.

CONCLUSIONS

Experience to date indicates that double check valves of the latest improved type, such as specified by the Associated Factory Mutual Fire Insurance Companies, provide as complete protection as any mechanical contrivance can furnish against pollution of potable water supplies through cross connections. If such devices are properly installed, inspected and maintained, the danger of contamination through cross connections so protected is very slight. In fact, the danger of pollution from such a source appears to be less than that due to possible failure of disinfection, where dependence is placed upon a single chlorinator. The danger still exists, however,

and because it may be less than some other dangers is no reason for permitting its continuance.

On the other hand, the possibility still exists that a double check valve may fail to act, and even monthly inspection cannot give absolute assurance that the apparatus will function perfectly at all times. Moreover, if such an apparatus does fail, the result may prove disastrous.

Therefore, even though the hazard of cross connections, protected by Factory Mutual double check valves, may be less than that from other sources with which water works superintendents have to reckon, the use of cross connections should not be continued, if it can be avoided. The danger, however, from cross connections which are protected by double check valves, *properly constructed and maintained*, does not appear to be sufficiently serious to necessitate extremely drastic measures for their complete abolition. I mean by this that, where the best modern appliances are installed, a requirement that they be eliminated forthwith or on six months notice would not be justified.

The sensible course appears to be to recognize that cross connections are always undesirable and that their complete elimination should be the ultimate goal; that no new connections should be allowed even with the best protection possible; that existing cross connections may in some cases be continued for a time, if Factory Mutual double check valves are properly installed and maintained, but that after a time even these connections should be eliminated.

It is probable that the procedure adopted in New York State of setting a date for the removal of all such connections is the wisest course to adopt. In some places and under some conditions, as where the original notice was short or where there may be great difficulty in separating the pipes without introducing greater dangers than would be eliminated, it may be expedient to extend the time for total elimination; but the object should be to attain that condition as soon as is reasonably possible.

UTILITY ACCOUNTING AND FINANCING[1]

By J. Joseph Hail[2]

Any business endeavoring to succeed must be founded upon a sound financial basis, whether it is municipally or privately owned. The owners of a private utility are stockholders, and take profits on their investments through dividends. In the municipal utility the consumers, or tax-payers, are the stockholders, and do not directly receive dividends, but indirectly share in the profits, by being served free water for fire protection, street flushing, park sprinkling, etc. along with the rate adjustments, no tax levy, and other advantages.

Adequate bookkeeping and accounting must prevail, in order to obtain efficient and accurate results. The first and most important division to consider is the "net income account," which shows in detail the operating and non-operating revenue, and operating, maintenance, depreciation, sinking fund, and depreciation reserve expense. This makes known to the stockholders or consumers the net income and the sources and amount from which the income was derived and for what it was expended. It also reveals the proprietary increase for the year, and the amount available for betterments. This amount may be spent for new equipment and extensions, which are betterments, and increase the fixed assets of the utility. A statement exemplifying the additions and constructions, along with the sale of old equipment and depreciation reserve, enumerates the exact amount the plant has increased or decreased during the year. This difference added or subtracted from the value of the preceding year is the present valuation.

The "balance sheet" is the most essential and interesting statement in any financial report, because from it you may visualize the assets you have, the liabilities you must meet and, most importantly of all, it enumerates the proprietary interest or what the public utility is worth to the city or corporation at the present time. Let us first consider the fixed assets and liabilities. These assets include the total value of land, buildings, distribution system, equipment, etc.

[1] Presented before the Iowa Section meeting, September 29, 1927.

[2] Accountant, Water Works, Dubuque, Ia.

undepreciated. The fixed liabilities should contain the depreciation reserve on the fixed assets and the bonded indebtedness. The difference between these assets and liabilities is the present value of the entire plant. A detailed inventory of repairs, tools, supplies and stock on hand will help to determine more accurately the operating, maintenance and betterment costs. The current assets disclose the amount of cash in the general or current fund, the accounts receivable, and all cash paid in advance, such as insurance. The current liabilities are the accounts payable and cash deposits, which must be refunded at a later date and for which you are liable.

Every well organized concern establishes "reserve funds" for depreciations, bonded indebtedness, and the interest expenses. A large enough reserve should be set aside for depreciation so that any part that becomes useless or inefficient may be replaced. Capital outlay may be financed by net income, bond issues, consumers assessments and contributions. In Dubuque a bond issue was preferred. The present bonded indebtedness is $355,000 which is being financed by a sinking fund, established in April, 1926. In order to take care of all bond interests and maturities, without any tax levy to the citizens, $2700 is transferred each month from the general fund to a sinking fund. The surplus is invested and the interest received must be deposited into the sinking fund.

The city is paying the water works about $26,000 per year for fire hydrant rental. In turn the water works pays the city interest on $545,000, which was the purchase price in 1900. This makes an annual expenditure of $25,929.36. The city is also charged $1800 per year for street flushing and makes a charge to the water works for the same amount for office and garage rental. These amounts practically balance and show that the water works operates on its own receipts without any outside help.

Every municipal utility is required by law to compile a "budget." This should not be considered a matter of form, but must be carefully prepared and lived up to, so that when the fiscal year ends a balance may be shown instead of an overdraft. The cash book is helpful in compiling any budget, because a budget should not exceed the amount of cash on hand, plus your estimated receipts, unless some other means of financing is used, such as a bond issue.

The operating maintenance, depreciation, sinking fund and total expense per thousand gallons, together with per cent of salable water, and pumpage accounted for determine the rates that should be

charged, and enable the consumer to know that he is receiving water at the lowest price possible under the present plant conditions.

One of the principal reasons for the success of any business is the practice of economy, which should prevail at all times. Competitive bidding for equipment, material and supplies purchased is a saving to any concern. It enables you to get more value for the amount expended. A check should be kept on all employees, both on the supplies and material they use, and the work they do. For example, at the stations, the production cost per unit thousand or million each month, the number of hours each machine is operated, a report on all break-downs, meters and gauges will enable any plant to operate and maintain as economically as possible. The distribution system and meters should be indexed and inspected often, so that in case of emergency any information desired may be found immediately. A record of repairs made, including the size, make and style should be indexed, so that when additional purchases are made the most economical make will be purchased. If all of these features are enforced a low operating and maintenance expense will prevail and the net income for the year will increase.

The consumers accounts, which contain over 90 per cent of the gross income, must be increased if the department wishes to prosper and expand. Accurate and up to the minute records enable any business to satisfy its users or patrons. If they complain that water is too high you must try and convince them that they are wrong. The cost of city water to the minimum user in Dubuque is about 2½ cents per day for drinking, bathing and cleansing purposes. This is about the cost of a postage stamp, an ounce of beefsteak, a pound of flour, half of a cheap cigar, or three cigarettes. For this half a nickel a day the water works delivers into the home 625 pounds or 75 gallons of water, and if this water were frozen into ice it would cost about $2.50. By this comparison you can see for yourself that no other item on the home menu is as cheap as water. Strange to say many people complain and abuse the employees of the water works if their bills exceed the minimum rate to the amount 25 cents in a quarter. The public little realizes the cost of hundreds of miles of mains, thousands of gate valves, pumping equipment, wells or filtration plants, which are all necessary to provide an adequate supply of water at all times. It also must be remembered that all machinery and equipment must function every minute of the twenty-four hour day.

In changing to the city manager plan in 1920, the city council and manager automatically became the heads of the departments. After a careful investigation by the council and manager the recommendations of the Fire Underwriters were approved. Engineers were employed and contracts were awarded for new buildings and equipment. Work was started in 1922 and finished three years later. $375,000 worth of improvement bonds were sold to help cover the cost of the new improvements, which amounted to about $700,000.

A new fire proof pumping station was built. This plant was equipped with a 6 and 8,000,000 gallon electric driven centrifugal pump, two 2500 cubic feet per minute air compressors, venturi meters, a new artesian well 1500 feet deep, and a 30-inch discharge line. A fire proof booster station was constructed to pump water to the Delhi Street standpipes. This station was equipped with two 3,000,000 gallons electric driven centrifugal pumps, venturi meter, and an automatic electrical start and stop control. The water storage supply was increased on the low pressure by covering a 7,500,000 gallon reservoir, which had been of no use, and now holds a two day reserve supply. On the high pressure a new 600,000 gallon standpipe was erected and increases the reserve from 400,000 to 1,000,000 gallons.

When the plant was purchased in 1900 the city found itself in possession of 44 miles of mains, 340 fire hydrants, 540 gate valves and 1854 taps. During the first twenty years under the management of ward aldermen and trustees there were added to the distribution system, 22 miles of mains, 98 fire hydrants, 358 gate valves and 3615 taps. Since 1920 up to the present time, under the manager form of government, 32 miles of mains, 252 fire hydrants, 772 gate valves and 3594 meters have been added, making our distribution system consist of:

98 miles of mains,	an increase of 47 per cent since 1920
690 fire hydrants,	an increase of 58 per cent since 1920
1,670 gate valves,	an increase of 86 per cent since 1920
8,190 meters,	an increase of 55 per cent since 1920

SERVICES IN ADVANCE OF STREET IMPROVEMENTS[1]

By C. E. Stewart[2]

We have not been very successful in our city in having the co-operation of the board of public works in helping us to complete service connections before permanent paving is done. Where it is necessary, we put these services in and try to collect from the property owner. In most cases we can collect, but there are a good many cases where we cannot. Where we collect from the property owner we put an account in our ledger and keep under this account the costs of the material, labor, etc., as a credit on our ledger. When the service is put in he is permitted to use that much water before he is made any charge. That seems to be the only way we can do it, but it is awfully difficult to do. The connections must be put in before the streets are paved and if the property owner does not pay it, it is handled as a lien and collected just as any other lien is collected.

[*The following experience was recorded at the meeting following Mr. Stewart's paper—Editor*]

Evansville: We install services and charge the immediate property owner for these services. If they do not pay it, we add it to the tax assessments.

Kokomo: We have a city ordinance providing if the city is to put in the paving we make a survey and furnish the city engineer and contractor who has the work a list of the lot numbers and sizes of service we think should go to the lot. This amount of money is added to the assessment roll. The contractor advances the money to us before he starts to work. The contractor pays us for the estimated amount of services and this is added to the assessment. When the service is used we refund to the consumer. We collect for ½-inch service, $25.00, and for ¾-inch $32.00. We carry these funds under an

[1] Presented before the Indiana Section meeting, March 16, 1928.

[2] Superintendent, Water Works, Muncie, Ind.

account listed as "Service Deposit" in the ledger, we can take off a trial balance at any time.

Evansville: On non-improved streets we charge $10.00 for the service. This amount is charged to the contractor who puts in the street. He takes it over to the county or city clerk who takes it to the Board of Works. They add a charge of $1.00 to the charge we made and add it to the assessment roll. The charge then corresponds with our books.

Question: Do you refund that to the consumer when he takes service?

Evansville: No. For improved streets we charge $25.00, brick streets $15.00 and for unimproved dirt streets, $15.00.

Richmond: For a number of years through the coöperation of the Board of Works, when a permanent improvement is to be made, the city engineer notifies the property owner that gas, sewer, and water must be installed. He indicates where the water taps are to be made and notifies the water company where the services are to be located. The record is sent to the Board of Works, added to the list of assessments of the property owners, in the city treasurer's account, and the water company is reimbursed for the actual cost of services. The water company has to lay all services to the curb, except in this case. After the owner makes application for water, the company refunds the cost of those services to the curb. There is no revenue until the service becomes revenue-producing. We refund the actual cost at the time it is put into service.

Evansville: When you figure actual expense of refunding you are figuring overhead in general office, etc. Can you figure overhead in ledger and journal entries and construction? I do not see how you can figure insurance and time of making ledger entries, etc.

Richmond: We add 10 per cent to the cost.

Lafayette: We have an ordinance to cover this matter. We proceed in this manner: We require on applications for water the advance sum of $30.00. This $30.00 becomes a rebate in water rent until

it is used up. We proceed in this manner on hard surfaced streets. We place the regular ⅝-inch service to the edge of the lot. We notify that the service has been put in. We give a description of the service and when the property becomes a consumer, they get credit for water rent to the amount of $30.00. We get along very nicely. Most of them are glad to know they have water when they come to sell the lot. If it is not paid we certify it to the Board of Works and in that way to the city treasurer, showing a lien on this property. It becomes a refund in water rent later if it is not put in use for ten or twenty years. We could charge 6 per cent on these deferred payments, but we have not carried this out yet. The Acts of 1927 require platted ground to put in these services.

Evansville: We charge $10.00 a service for unimproved dirt streets, $15.00 brick improvement, and $25.00 for asphalt before these services are installed. We do the best we can. We send postal cards, as a great many of these people live out of town.

Lafayette: We do not call it charge; an advance is what it really is. We send a letter stating that it is payable by a certain time. If they fail to pay it, we certify it to the Board of Works, Controller and City Treasurer. When they come to pay the taxes the Treasurer informs them that water has been put in and that we require the payment of $30.00 from each applicant. We go ahead and do this and notify the owner it has been done. Very few unpaid services are put in on account of the hard paved streets.

Evansville: If you would make a charge of so much to each property owner regardless of whether on the near or far side of the street for each service installed on the property, you would eliminate a great deal of trouble.

Richmond: A uniform charge would be very desirable. That matter was taken up before the Commission. It seemed fair to make the same charge to the property owner on either side of the street. They said "No." They said "you must make it the actual cost. The short side of the street has the advantage."

Evansville: It would hardly be fair, if you spent $8.00 for a short service, to charge $18.00. I think you should bear that cost. If you

buy a lot, you do not go down to the Board of Works to find out on which side of the street, far or near, the gas or water main is. Why should not the owners on either side of the street pay the same price?

Columbia City: We are going ahead and making service taps, putting in the work and material at cost. We give the porperty owner thirty to sixty days to pay. We have never had any trouble in collecting our accounts. We make no refund whatever. It is a publicly owned plant. The property owner takes care of his service from the main to the curb and into the house. Everything is satisfactory. The water company, municipal or private, should run the service to the curb free to the consumer. They would have to rebate to every consumer from the main line to the curb, the cost of the labor and material. Of course, it is more on the long side of the street for labor and material. We do not aim to make any profit. We charge just what it costs. If we pay labor 40 cents an hour, we charge the consumer 40 cents an hour, and material the same. We keep that cost down as low as possible and we have no trouble.

Richmond: Our company does not consider the 10 per cent profit. The 10 per cent is to cover insurance, superintendence, and legitimate additions to the cost. It is not a profit. It is incidental and intangible.

REFORESTATION OF WATER SHEDS[1]

By Edgar P. Kable[2]

Municipal water supplies are usually secured from rivers, lakes, springs or wells. Surface streams are usually the supply for the larger communities and these bodies of water are replenished by moisture reaching the drainage area in the form of rain, snow, hail, dew, frost and similar forms.

It seems desirable, but usually not practicable, for a water works to own its entire water shed. A large percentage own practically none of the land on which the precipitation falls and only a few plants own the entire drainage area above their intake. The latter are usually in mountainous sections. The situation in some cases is controlled by the water works authorities leasing the water rights on the shed.

The health and comfort of mankind are directly influenced by forests and pure water supplies. The latter in most cases cannot be obtained without the former. The prevention of pollution of water supplies is the problem confronting all water authorities. This condition has been much aggravated by the general use of the automobile which has brought the population to the most remote spots in recent years. Excreta from a typhoid fever patient may find its way to a stream, and there may be other contamination from farm buildings, etc.—all of which so often result seriously. If it is the desire of the authorities to serve the public with water without extensive filtration and sterilization, the entire area over which the rain and snow collect must be owned by the water works or managed solely in its interest, assuming of course that the water shed is inhabited or not exempt from pollution.

Since it is found impracticable to own or control directly the entire catchment area, it becomes desirable to prevent as much as possible the pollution of the main streams. The control of the land directly bordering on these streams and regulation by appropriate acts

[1] Presented before the San Francisco Convention, June 14, 1928.

[2] General Manager, York Water Company, York, Pa.

of the legislatures of the various states and counties to prevent pollution of the public water supply are perhaps the most that the water authorities can expect to accomplish.

The areas thus acquired cannot be left to remain barren and unprofitable. To use them for raising the average farm crop when it is necessary to plow the soil annually is undesirable. The planting of these areas in grass and using them for the grazing of sheep and cattle is equally undesirable.

The planting of trees seems to offer the greatest benefits. They offer some profit, the amount depending on the location and species planted; prevent trespass where planting is sufficiently close; prevent erosion of the soil into the stream; in most cases prevent a rapid run-off of the flood waters thereby increasing the normal flow of the stream. But above all the appeal which a forest makes to the water consumer is of great value to the water department at present and the profits from the sale of timber will be received by future generations for which I am sure they will be grateful.

Many factors enter into the question of species of trees to plant. In undrained soil it is difficult to plant trees successfully and likewise in a high altitude, yet every available tract bordering a stream used as a water supply should be covered with trees of the variety best suited to the particular locality.

The splendid coöperation of the forestry departments of the various states and federal government through their various bureaus and departments with the water works authorities is highly commendable and often they have shown the way and contributed to the successful reforesting of the water sheds of municipal and private water works. These agencies have their nurseries and experimental stations and can advise intelligently regarding the proper trees to plant at the different locations.

Too often, for political reasons or otherwise, the authorities, after acquiring property along the stream and reforesting it, turn it over to the general public for recreational purposes which attracts hunters and fishermen. After being open for some time the purpose for which the property was acquired is lost sight of and the land ruined so far as conserving and protecting the public water supply is concerned. Frequently the consumer who is also the taxpayer will trespass saying he is part owner and should be excused and it is trying to water works authorities to turn down his demands. The Department of Forestry of the State of Pennsylvania has admir-

ably coöperated with the water authorities of that State by promulgating a set of rules governing camp sites on water sheds of streams in the state owned forests. These rules, which are rigidly enforced, prohibit camping within certain distances of intake dams of public water supplies. A water shed used for the collection of water for a public water supply cannot be used with success jointly for recreational purposes and the water works authorities should have the support of every citizen to protect the forests where trees stand as vast armies protecting the health of us all.

I join with some of my colleagues in the water works fraternity that it be made compulsory for those who secure their supply from the surface of the ground to reforest the border of the streams above the intake in order to protect and preserve this most vital necessity.

The water works authorities, being so busy protecting their supplies, rarely consider that by reforesting their sheds they increase the timber reserves and are creating an asset which is becoming more valuable every year. The "harvest is on" almost from the start if properly planted. If evergreens are used and planted close some can be removed within a few years and readily sold as Christmas trees, leaving the remainder to mature. With the exception of a few varieties, after once a tract is completely planted, it will perpetually regenerate or maintain itself by the falling of the seeds to the ground beneath and the sprouting of the same. This natural regeneration can be assisted by the sowing of additional seed at the thinner stands.

Difference of opinion, which is to be expected, has arisen as to the degree of influence the forest has on the water supplies. This is due probably to the difficulties involved in accurately measuring their influences and to diversified interests affected, but I believe we are all of the opinion that we want to have with us in our daily lives both the forest and an ample, pure and wholesome water supply. Most of the observers also agree that the precipitation is the greatest over the forested lands. In this water works men are all most vitally interested as it represents our daily bread. The United States forest service tells us that the excess of precipitation over forested areas is in certain localities as much as 25 per cent.

The effect of the forest on the climate is probably not of interest here. The millenium will probably arrive before the engineers and foresters will agree on the amount of influence reforesting has on water supplies and climate. In level tracts where the precipitation

does not run off, the trees eventually drain the soil of the marshes and improve conditions hygienically. This is occasionally used as an argument that trees consume more moisture than they retain in the soil.

SELECTION OF SPECIES OF TREES

The species of tree to be selected for planting on a water shed depends on the locality, soil, elevation and effect of the leaves or other flowers which fall from the trees.

Some of the deciduous trees deposit leaves which within a short time mould in process of decay and impart an objectional odor, color and taste to the water which is eliminated with difficulty in the process of filtration. These leaves are also objectionable if they find their way onto the screens of an intake channel of a pumping station and obstruct the flow of the water.

This has been overcome in certain localities by planting evergreen trees along the waters' edge and planting the deciduous trees at some distance from the water. In this way the evergreen trees act as a barrier or trap and hold the leaves, where as the needles of the evergreens usually imbed themselves on the surface of the ground and rarely reach the water.

The evergreen tree where practicable to plant, appears to have some advantages over the deciduous tree for water shed protection in that the needles deposited beneath the tree create a soil condition which permits the precipitation more readily to penetrate the top surface of the soil, whereas the litter formed on the ground by the deciduous tree becomes wet and slimy with the initial rainfall and the remainder of the rain has a greater tendency to flow over the surface to lower points.

When a tract selected for reforesting is found to contain scrub trees of a different species from that intended to be planted, it becomes necessary to cut down these scrub trees and cut their sprouts annually for the first three or four years as this growth shades out the new trees. This is particularly true of cases where hardwoods are replaced with conifers.

A very important matter to be considered in the outset of a reforesting project is the selection of the size of tree. A seedling tree is one that has grown in the nursery or set in a bed for two or three years from seed during which time it has not been transplanted. Transplants vary depending upon the kind and duration of the trans-

planting period. The expression "1–2 transplant" means that when the seedling was one year old, it was transplanted and then remained in the nursery for two years more giving it a total age of three years. The expression "1–2–1 transplants" means that when the seedling was one year old it was transplanted and after two years it was transplanted again and then remained in the nursery for another year, giving it a total age of four years. The expression "2–2 transplant" means that the seedling was transplanted at the age of two years, and then remained in the nursery for two years more, when it had a total age of four years. The expression "1–2–2 transplant" means that the seedling was transplanted at the age of one year and after two years was transplanted, also again after two years was transplanted giving it a total age of five years.

The experience which I have had with planting has shown that too small a tree is equally as undesirable as too large a tree for successful reforesting. The loss the first year in using seedlings has been as much as 30 per cent. It is true that this 30 per cent can be replaced the second year, yet, as a rule, the labor of planting is the expensive part of reforesting. If a large tree, say a five-year transplant, is used the trunk is rather rigid and when the wind sways the tree it creates an opening in the ground down to the roots and permits the air to enter. A three year transplant seems to be the desirable tree to plant. The trunk is flexible enough to permit the wind to sway it back and forth without creating the objectionable air pocket. The systems of roots in this sized tree are numerous and compact. In the plantings at York, Pennsylvania, when over 100,000 trees were planted in a single season, the loss the first year was as low as 2 per cent.

PLANTING METHODS

When the trees are received from the nursery, great care should be taken in unpacking to see that they are not exposed to the air as the roots dry readily and the tree dies. Immediately after unpacking, the roots of the trees should be immersed in a compound of earth and water about the consistency of cream and then should be heeled in while in bunches in a furrow so that the roots and trunks are completely covered, letting only the top remain exposed. They can remain in these trenches while the planting is progressing. The time to plant will depend entirely upon the location, but it should be done

as early in the growing season as practicable. Spring seems to offer some advantages over fall planting.

Small nurseries located on a desirable lot adjoining a water shed are not only desirable, but profitable. Seeds or seedlings can be planted in rows and with very little care will produce plants suitable for forestry planting within three or four years at a nominal cost, with the added advantage that the plants are available for planting early in the season within the area to be reforested. This avoids the necessity of extensive packing and often long and expensive hauls with the accompanying losses in transit.

HAZARDS

The greatest enemy of the forest is fire. Fire originates in most cases from the carelessness of man and every precaution should be taken to protect the trees from this hazard. Fire lanes through the tracts should be provided where there is a sizable planting. These lanes should lead from the main highways and should be of sufficient width so that when the trees mature they will permit men on horseback to pass back and forth through the tract. It is impracticable to make the lanes wide enough to prevent the leaping of the flames across them. The number will depend on the species of tree planted and size and topography of the tract. These lanes should be kept mowed close to the ground and free from dry grass or other inflammable material. An equipment consisting of fire rakes, axes, approved chemicals or other extinguishes should be kept at convenient stations on the tract. If the forest is of sufficient size and so located that all trees cannot be observed from a common point, an observer's tower should be provided and observations made continuously, if the tract is used by the general public, so that the first curl of smoke can be detected and an alarm given immediately. Usually this manner is ably handled through the various state bureaus and every owner of a forest should be in close touch at all times and confer with the active heads of these bureaus. During the spring and fall seasons when most of the fires occur, the greatest precautions should be taken and during these times it is important that extra patrol be carried.

Another hazard is disease, but fortunately in this agency, the most fatal disease attacks only one species, as, for example, the chestnut blight attacks only the chestnut tree and the white pine blister rust

the white pine tree. By planting several varieties on the same tract the likelihood of total failure through disease is practically eliminated.

Through the prompt action of the Federal authorities and those of several of the states the blister rust appears to be under control at least for the present.

The white pine weevil also attacks the leader of the white pine trees and stunts its growth, but does not as a rule prove fatal to the tree.

The writer has had experience with apparent success with the planting of red pine, white pine, European larch, silver fir, douglas fir, hemlock and Norway spruce.

The impounding basin tract of The York Water Company located along the Susquehanna Trail four miles south of the City of York, Pennsylvania, and 45 miles north of Baltimore, Maryland, contains about 700,000 evergreen trees of the above mentioned varieties in a very flourishing condition. The land is rolling, being typical of Pennsylvania, and formerly constituted farm land in a high state of cultivation. This is the tract which the eminent authority, Dr. C. A. Schenck of Darmstadt, Germany, formerly director of the Biltmore Forest School, declared to be the best example of evergreen reforesting in the world. The first plantings were under the personal direction of Professor J. W. Toomey, Dean of Yale Forest School. Dr. Joseph S. Illick, State Forester of the Commonwealth of Pennsylvania and his staff and Major Robert Y. Stuart, now United States Forester, rendered valuable assistance. This tract is visited frequently by foresters of the various states and others interested in forestry and the management of The York Water Company will be pleased to have anyone visit the tract at any time.

Summarizing the subject, we find trees where there is water and water where there are trees. There are no trees where there is no water and no water where there are no trees. Water is what we want and by nature the trees follow. We believe we can hurry along more water by planting more trees, so let us help the coming generations by planting the forests and let them stand as our heritage.

It may not be amiss to quote Humboldt's saying: "How foolish is man in destroying the mountain forests, as thereby he deprives himself of wood and water at the same time."

DEVELOPMENTS IN WATER SOFTENING

By Charles P. Hoover[1]

Developments in water softening will be described in the following order: (1) handling of chemicals; (2) mixing devices; (3) Dorr clarifiers; (4) methods for further reducing hardness; (5) substitution of zeolite for soda-ash to remove non-carbonate hardness, and (6) recarbonation.

ELEVATING CHEMICALS TO STORAGE BINS

Methods for handling, storing and applying large quantities of chemicals were in the past crude.

Large quantities of chemicals can now be economically handled by unloading them from the cars by means of power shovels or by means of pneumatic conveying devices and they are cheaply elevated into bins from which they are subsequently fed into the water by gravity.

The pneumatic conveying installation consists principally of: vacuum pump, conveying line with intake nozzle, receiving station, and air filters.

The pump produces a vacuum through the filters, receiver and conveying line. The nozzle of the conveying line is inserted into the lime or soda-ash to be unloaded and elevated. The high velocity of air carries the material to the receiving station. On entering the receiver the velocity of flow is reduced by the sudden increase in volume in the chamber, and the material is dropped to the bottom of the receiver and discharged through a rotary lock into the screw conveyor which distributes the material across the top of the storage bins. The exhaust air is passed through the filters for the removal of the dust in suspension.

The principal advantages of this system of handling chemicals are: (1) elimination of the most laborious and disagreeable job about a water softening plant; (2) elimination of dust, thereby making it

[1] Chief Chemist, Water Softening and Purification Works, Columbus, Ohio.

easy to keep the plant clean; (3) saving effected by purchasing material in bulk.

Objection has been raised to this system for unloading lime on the grounds that the lime is brought in contact with a large volume of air and consequently there might be some carbonation. Carbonation of lime does not occur at all in perfectly dry air[2] and it is doubtful if the short exposure the lime has to air, even if a small amount of moisture were present, would result in much if any carbonation. Charles Spaulding,[3] chemist in charge of the Springfield, Illinois, plant states that he finds no difference in the analysis of the lime at his plant on samples taken before and after unloading from cars by means of the pneumatic conveyor.

APPLYING CHEMICALS TO WATER

In the early days of water softening, the common practice was to add saturated lime solution to the water to be softened. It was thought that, because saturated lime water was a true solution, it could be more readily applied in uniform quantities than milk of lime, and also the feasibility of thoroughly mixing raw water with milk of lime in large quantities was questioned. It was thought that the raw water and the milk of lime would not be adequately mixed, resulting in a marked loss in softening efficiency, owing to the fact that the suspended particles of lime (calcium oxide) would become coated with precipitated carbonate of calcium and magnesium hydrate, thereby becoming inactive.

Our experiences lead us to believe that saturated lime water reacts much more quickly than milk of lime, that it is much more difficult to prepare and apply to water than milk of lime, and that if milk of lime is adequately agitated with the water being softened that the results are just as good with milk of lime as with saturated lime water. Consequently, the practice of preparing and applying saturated lime water was abandoned.

It was also customary to add lime first and then after a definite period of time to add soda-ash. This was done on the theory that the lime would combine with the soda-ash to form sodium hydroxide which would absorb free and half-bound carbon dioxide, resulting in a wastage of soda-ash for doing work that should be done by lime,

[2] Depreciation of Quick Lime, Copeland & Sperry, Engineering News Record, May 13, 1911.

[3] Private communication.

a less expensive reagent. This theory was wrong because the absorption of carbon dioxide by the sodium hydroxide, results in the formation of sodium carbonate and it therefore apparently makes no difference whether the lime and soda-ash are added separately or together. In many plants using solution feeds, they are mixed together in the same tank and fed out as one solution.

Dry feed machines for measuring the chemicals and these same machines equipped with continuous lime slackers have been developed and their introduction permits of the elimination of chemical solution tanks with all their attendant difficulties, familiar to all water works operators.

At Piqua, Ohio, the chemicals drop from the bins through undercut gates to the weigh hopper. From the weigh hopper, the material flows into a feeder.[4] This feeder consists of a hopper, a cylinder provided with a piston, and means for adjusting the length of stroke of the piston. The piston is operated by a crank pin on face of gear driven by the main drive shaft of the lime slacker. This type of feeder has proved to be very accurate, but it is not necessary to depend entirely on the accuracy of the feeder, because the operator can see at a glance by looking at the weigh hopper scale, just how much lime has been fed during any interval of time. For instance, at Piqua, approximately 250 pounds of lime are required per hour when softening at the rate of 5 million gallons in 24 hours. The operator reads the lime weigh scale each hour, and if the feeder has not fed exactly 250 pounds of lime, it is adjusted. This results in very accurate application of chemicals to the water, which is one of the most important features of the whole process of water softening.

MIXING TANKS OR AGITATING DEVICES

Two types of mixing or agitating devices have been used at water softening plants: (1) baffled tanks with various combinations; (2) mechanical agitators. The over and under type baffled tanks have been successfully used at the Columbus plant for the past 20 years. The type of agitating device used at Sacramento based on the result of experiments made on Sacramento river water using mechanical mixing in accordance with certain principles previously discovered by Prof. W. F. Langelier during laboratory research work at the University of California. The structural and mechanical design of the full sized units was carried out under the direction of Charles

[4] Feeder manufactured by French Oil Machinery Co., Piqua, Ohio.

G. Hyde, chief consulting engineer on the Sacramento filtration project. This type tank has been used at the water softening plants at South Pittsburgh, Pa.; Miami, Florida; Springfield, Illinois; Hinsdale, Illinois and Piqua, Ohio.

The paddles are swung from the paddle arms by means of plate clamps, the paddles thus being allowed to assume a more or less horizontal position when the agitating device is started, but the weight of the paddles is such that, when motion in the tanks is obtained, the paddles assume a vertical position. This is to take the load off of the motor in starting up the agitators.

The relation of the area of the paddles to the area of the central vertical section of the tank is 25 per cent. Even with this large paddle area uniform velocities are not maintained.

There seem to be two zones, an inner and outer one. The inner zone is from the center to about one third out and the outer zone from there on to walls of the tank. The velocity is too low in the inner zone and scarcely any floc can be seen whereas in the outer zone, very satisfactory floc formation is obtained.

In a modification of the type described, instead of discharging the water from the side of the tank, it is discharged through a take off pipe from the center. This modification prevents short circuiting of the water through the tank and more uniform velocities are obtained.

The baffled tanks as built at Columbus are satisfactory and none of the mechanical tanks already built give any better results, but mechanical tanks are less expensive to build and they remove the necessity of lifting the water the extra two or three feet necessary to pass it through baffled mixing tanks, and although agitators require power to keep them running, the cost of operation, if proper drive is provided, should be less than the cost of the additional lift of the water. They also provide greater accessibility and flexibility.

DORR CLARIFIERS

The disposal of the large quantities of sludge formed by the softening reactions was a problem in the past, especially when a water softening plant was built along a small stream.

It was the custom, and still is at a few of the older plants, to allow the sludge to accumulate in the settling basins and to discharge it from the basins intermittently. At the Columbus plant the sludge

is held for a period of 30 days, and one of the disadvantages of doing this is that on each successive day the capacity of the tank decreases. Another disadvantage is that when the sludge is discharged in such large quantities into a stream, especially one as small as the Scioto river, it causes the stream to become very unsightly.

Apparatus has been developed which may be installed in the settling basins or clarifiers making it possible to remove the sludge produced from the water softening reactions continuously. Practically all of the municipal water softening plants built within the last five years have been provided with Dorr clarifiers for removing sludge continuously. There is a difference of opinion as to the merits of the round versus the square tank, and there is also a great deal of discussion as to the best method of flowing the mixed water from the mixing tanks into the clarifier. These differences will not be discussed in this paper, but will be left open for any discussion that may follow.

METHODS FOR FURTHER REDUCING HARDNESS

In the early days of water softening, limited results were obtained in reduction of hardness on account of the formation of soluble complex basic carbonates of magnesium which may be represented by the following formulae:

$$Mg_4(OH)_2(CO_3)_3$$
$$MgCO_3 \cdot NaHCO_3 \cdot 4H_2O$$
$$MgCO_3 \cdot Na_2CO_3$$

These soluble salts cause the alkalinity of the softened water to be high, especially when soda-ash is used along with the lime to reduce non-carbonate hardness. Consequently water that is high in non-carbonate hardness is more difficult to soften than water with an equivalent amount of hardness, but low in non-carbonate hardness.

The limitations in the reduction of hardness have been largely overcome by (1) the hot process; (2) excess lime treatment; (3) split treatment; (4) excess lime followed by carbonation; (5) the use of compounds of aluminia; and (6) substitution of zeolite for soda-ash to remove non-carbonate hardness. These processes are explained in detail by the author in Industrial and Engineering Chemistry, May, 1927, Vol. 19, No. 5, and only the last one will be discussed in this paper.

SUBSTITUTION OF ZEOLITE FOR SODA-ASH TO REMOVE NON-CARBONATE HARDNESS

Where salt may be obtained at a fair cost it is cheaper to remove non-carbonate hardness by means of zeolite than by means of soda-ash. At Columbus, the discontinuance of the use of soda-ash and the substitution of zeolite equipment is being seriously considered. If adopted, the entire supply of water treated, will be softened with lime, coagulated with alum, settled, and carbonated; then a sufficient quantity of it will be softened to zero hardness by zeolite so that by mixing the zero water with the lime softened water the resultant mixture will have the desired degree of hardness. At the Columbus plant $115,000 is spent annually for soda-ash. It is believed that a plant for zeolite treatment can be built for $200,000 and that by investing this amount the City of Columbus can save enough from operating expenses to pay off the entire investment in 20 years, and, in addition, save, from $20,000 to $30,000 per year, depending on the hardness of the softened water desired.

LIME SOFTENED WATER NOT STABLE

Lime softened water is not stable, because it is super-saturated with normal carbonates of calcium and magnesium, and distribution systems carrying the water become incrusted with deposits of the carbonates. Difficulty with the deposits is also encountered in meters and hot-water systems, especially hot water pipes in hotels and public buildings, because the water in these buildings is usually heated to a temperature higher than the average.

The filtration of lime-softened water through sand filters has a very bad effect on them, because the normal carbonates crystallize onto the surface of the sand grains, covering them with an adherent coating and causing them to grow in size and finally to lose their effectiveness as a filter medium. The sand grains not only grow in size, but they also cement themselves together, forming hard lumps in the filters, and the water to be filtered will not pass through them. Once or twice a year it is necessary to spade up sand filters, crush all hard lumps, and after seven or eight years of service the filter must be rebuilt. Lime softened water has the same effect on green sand or zeolites as it does on ordinary filter sand.

RECARBONATION

Lime softened water may be cheaply and satisfactorily stabilized by recarbonating it with carbon dioxide gas produced by burning coke, pulverized coal, oil, or gas in a suitable furnace and forcing the gas after being passed through a scrubber and dryer into the water. This gas is diffused into the water through small openings in a grid system, and is applied after it has passed through the settling basins and before it reaches the filters.

FUELS FOR CO_2 PRODUCTION

A carbon dioxide plant should deliver as high a percentage of the gas as controllable combustion will permit. The available fuels from which carbon dioxide can be obtained are coke, which yields about 3 pounds of carbon dioxide from 1 pound of fuel; artificial gas, which yields about 80 pounds of carbon dioxide from 1000 cubic feet burned; natural gas, yielding about 115 pounds per 1000 cubic feet burned; kerosene or similar oil, which yields about 20 pounds of carbon dioxide per gallon burned; and producer gas made from coke, yielding about 3 pounds of carbon dioxide for each pound of coke gasified.

In a small plant the fuel expense is practically negligible, and gas is really the most suitable fuel because the equipment can be almost entirely automatic. The next most convenient fuel is kerosene or similar oils, which when properly burned give products of combustion that are tasteless and odorless and in every way suitable for recarbonation of water. The products of combustion from burning these fuels contain about 12 per cent carbon dioxide. The burning of coke in an ordinary furnace or stove produces a gas containing only from 4 to 6 per cent carbon dioxide, therefore, a much larger air compressor must be provided for forcing the gases into the water than where the other named fuels are used.

PLANT AT COLUMBUS

For large installations producer gas made from coke and then burned to complete combustion under proper conditions is the most economical method for obtaining carbon dioxide. Such a plant has been built at the Columbus water softening and purification works. The gas-making plant consists of six principal parts—a gas producer, a gas burner, a return tubular boiler, a steam driven air compressor,

a combination scrubber and drier, and a diffuser. In operation, coke is burned in a gas producer, which is a closed furnace with controlled air supply furnished by a blower. The products of combustion pass from the gas producer to a gas burner, where they are mixed with air and burned to complete combustion under a boiler. The steam produced in the boiler is used to drive the air compressor and blower in order to make a closed cycle for the process or, as the plant is located in the boiler room of the pumping station, the steam produced is connected with one of the main steam lines. The air compressor takes its suction from the boiler stack of the producer gas-burning boiler, through a scrubber and drier, and forces the washed gases through diffusers into the water to be carbonated. Making producer gas from coke and burning it under a boiler is perhaps the most economical method of producing carbon dioxide gas, because the steam generated is readily available and it is possible to produce a gas containing as much as 19 per cent carbon dioxide, thus requiring an air compressor of only one-fourth the capacity necessary if coke were burned in an open furnace.

ACTION OF CARBON DIOXIDE ON SOFTENED WATER

The carbon dioxide gas converts the normal carbonates, which are only slightly soluble, to bi-carbonates, which are highly soluble, and will therefore not be easily precipitated from the water.

At almost all of the water softening plants now operating recarbonizers, just enough carbon dioxide is added so that the carbonated water shows a slight trace of color when phenolphthalein is added, the carbonated water having a pH of from 8 to 8.5.

Some water softening plants are reducing the hardness of the softened water to a standard ranging from 100 to 125 p.p.m. Other plants are reducing the hardness to a standard ranging from 80 to 100 p.p.m. Still other plants are reducing the hardness to a standard ranging between 50 and 70 p.p.m. At the plants reducing the hardness to only 100 p.p.m. or more, the water is treated with only sufficient lime to neutralize the free and half bound CO_2 and to precipitate part of the magnesium. In other words excess lime is not used. Operating on this kind of a schedule, that is without excess lime, it is probably best to carbonate the water just before it goes to the filters. There are two advantages in doing it this way. First, better bacterial removal will be obtained by having the water in the settling basins containing normal carbonates or perhaps with a few

parts of caustic alkalinity, than with a water having bi-carbonates. The second reason is that the basins provide a longer time for the reactions to be completed. Reactions of course are brought to an end as soon as CO_2 is introduced.

By excess lime treatment practically all of the magnesium present in the water may be precipitated and if the excess lime is neutralized with CO_2, alkalinities as low as 20 to 30 p.p.m. may be obtained in the softened water. When excess lime is used there are several procedures of carbonation that may be followed. First, carbonate the water with enough CO_2 to neutralize the excess lime or caustic alkalinity. This converts the $Ca(OH)_2$ into $CaCO_3$ and if the caustic is high, a secondary precipitation will be produced. This secondary precipitation may be settled or filtered out. If two settling basins are available the caustic water may be allowed to pass through one basin after which it is carbonated sufficiently to just neutralize the excess lime; then passed to the second basin where the secondary precipitation may be settled out. The water should then be given a second carbonation treatment in order to convert the normal carbonates to bi-carbonates. If however, the water is carbonated just before it goes to the filters and the excess lime is converted to $CaCO_3$, this secondary precipitation of $CaCO_3$ will be caught on the filters and can be easily washed out. The precipitated $CaCO_3$ does not cause any difficulty in the operation of the filters, that is, it does not encrust the sand grains like normal carbonates that are in true solution or as a saturated solution.

RECARBONATION SHOULD NOT INCREASE CORROSIVE PROPERTIES OF WATER

The advisability or recarbonating a lime softened water has been questioned on the grounds that the release of the carbon dioxide in hot water would result in an increase in corrosiveness. This might well be true if one put in too much CO_2 so as to get aggressive CO_2 but this would be unwise for two reasons: first, it would be wasting CO_2, and second, it would cause corrosion. It should be understood that the recarbonated water does not contain any dissolved or free carbon dioxide as only a sufficient amount to chemically combine with the normal carbonates is added.

Carbonation of a softened water makes it resemble natural water. A water works chemist can very easily identify a sample of lime softened water because of its difference from natural water. He could not, however, identify a lime softened water that had been

carbonated because the results of analysis would be similar in all respects to any natural water of similar hardness.

Many cities are adding lime to their water supplies to prevent corrosion and when lime has been added to a natural water in sufficient quantity to increase the pH to 8 or 8.5, it will exactly duplicate lime softened carbonated water of equal alkalinity. Baylis[5] found that by adding lime to the Baltimore city water so that the pH was increased to 8.5, corrosion was practically eliminated. Carbonation plants have been in operation now for the past five years and during this time no increase in corrosion has occurred. Objection has also been made to using lime softened carbonated water in boilers on the assumption that it would be more corrosive than the uncarbonated water. Barr and Savidge[6] state that by far the greatest number of waters used by the railroads of this country are substantially neutral, having a pH value of 5 to 9 and that their corrosive action is due to dissolved oxygen. It is inferred from this that corrosion is independent of the reaction of the water as long as it is in the neutral zone. This is also borne out by Foulk[7] who says: "Experimental evidence seems to show that from about pH 11 to pH 5, the rate of corrosion is independent of the hydrogen-ion concentration and the only controlling factor in this range is the concentration of oxygen." He also states that from pH 4 and on to greater acidities, the rate of corrosion is proportional to the hydrogen-ion concentration.

Koyl,[8] Engineer of Water Service, Chicago, Milwaukee and St. Paul Railway, says that carbonic acid never does any damage to the water covered parts of a boiler unless there is a large amount of oxygen also present.

If, as has been stated, the hydrogen-ion concentration is not a factor in the rate of corrosion between pH 11 to pH 5, then the lowering of the pH of a lime softened water by carbonation to 8 or 8.5 would most certainly not increase its corrodibility.

ADDITION OF ALUMINUM SALTS TO LIME SOFTENED WATER NOT A SUBSTITUTE FOR RECARBONATION

It has been claimed, by those interested in the promotion of the sale of sodium aluminate, that, if sodium aluminate is used, incrusta-

[5] The Journal, 15, 6, June, 1926.

[6] Transactions, American Institute of Chemical Engineers, Vol. 18, page 69.

[7] Industrial Water Supplies, Geological Survey of Ohio, Bulletin 29, page 99.

[8] Private communication.

tion of sand grains through which the water is filtered will not take place and also there will be no trouble from deposits in the distribution system. Aluminum sulfate has been added to the Columbus water for the past 20 years, and, as a result of this, deposits on the sand grains and the distribution system have been kept at a minimum, but we do not believe that it would be possible by the introduction of an economical amount of aluminum sulfate or sodium aluminate for a municipality to produce an entirely stable water.

Baylis[9] has shown that a low alkalinity water, such as that produced at a municipal softening plant, will deposit calcite coatings when the pH value is 8.5 or more and lime softened sodium aluminate treated waters have a pH exceeding 10.

Municipal water softening plants usually soften to from 70 to 100 p.p.m. Such a water will be saturated with calcium mono-carbonates and inferentially, but certainly, unstable. It may be, however, that, if water is softened to 25 to 30 p.p.m. hardness by excess lime and soda-ash treatment and then treated with aluminum sulfate or sodium aluminate, it will be stable, because under these conditions the mono-carbonate concentration may be below the saturation point.

DISCUSSION

August V. Graf, (St. Louis, Mo.): I might add a little to the history of recarbonation of water.

A great many people believe that recarbonation is just a recent development, but in 1904 a patent was granted Archbutt and Deeley on the use of carbon dioxide on softened water and two municipal plants, one at Swadlincote and the other at Ashby, used this method of treatment.

In the Engineering News of 1898, December issue, you will find a very interesting article dealing with recarbonation in which is also mentioned the use of sweeps for the continuous removal of mud from the basins and also the use of part of the precipitated matter for hastening the chemical reaction. This is a very interesting article and should prove of great interest to all men interested in softening.

Charles H. Spaulding (Springfield, Ill.): I might say a few words about the carbonating equipment at Springfield, Illinois, which has been in operation now about six weeks.

Stack gas is taken from the boilers at the power plant. The boilers

[9] Paper read before the April, 1927, meeting of the American Chemical Society.

are fired with bituminous screenings, a poor grade of fuel, and we anticipated some trouble. We have had none so far. The gas is scrubbed in a simple gas scrubber consisting of a tower containing wood trays over which water is trickling. We use about 30,000 gallons of water per day for the scrubbing. The next step is the dry scrubbing and then, instead of a reciprocating compressor such as Mr. Hoover mentioned, we use a rotary blower.

I had some experience in Oklahoma City, and I do not know whether Mr. Flentje, who is there now, will report the same, but we had a lot of corrosion in the valves of the compressor of the reciprocating type. The machine which we are using has given us no trouble from gumming up or from corrosion, so far as we know.

The Springfield plant is merely mentioned at this time, because, in spite of apparent economy, stack gas from bituminous coal has proven unsatisfactory elsewhere for carbonating water.

F. H. WARING (Columbus, Ohio): I should like to comment on a few features of this water softening problem as presented by Mr. Hoover.

First, in regard to the possibilities of the water becoming corrosive as a result of recarbonization. As he said, we have seven plants in Ohio, operating on the recarbonization basis. The oldest one in service is at Defiance, installed in August, 1921. At that plant it had been and still is the practice to control the application of carbon dioxide so that the water coming to the filters contains about 2 p.p.m. of free CO_2. The next plant in service in point of age was Newark, which was placed in service in March, 1924. At that plant it had been the practice to control the application of carbon dioxide so that the water supplied on the filters contains about 4 or 5 p.p.m. of normal carbonate alkalinity. The experience which we have had with these plants seems to indicate that whenever there is a slight excess of CO_2 or slightly under the neutral point there is no corrosiveness imparted to the water so treated. We advise that the treatment be so conducted that there will be practically no free CO_2 in the water going to the filters.

Another aspect in treatment for softening purposes I want to enlarge upon is the bactericidal effect you have when you soften to an excess. That was not stressed particularly in Mr. Hoover's paper, but it has a definite application in many of the Ohio plants. Mr. Hoover noted as early as 1908 that the water supply at the Columbus plant was rendered practically sterile by the excess lime

treatment. That is, the water from the settling basins coming to the filters ordinarily showed no bacterial life.

We have taken advantage of that knowledge. In 1918, Mr. Hoover recommended to the city of Youngstown that they resort to excess lime treatment primarily for the bactericidal effect to be obtained. That plant has been in service on that basis for the last nine years and the water is uniformly free from bacteria as a result of the treatment. Other plants have also combined the two ideas, softening plus bactericidal effect, to advantage. The Piqua plant referred to by Mr. Hoover is treating water from Miami River which contains at times a large amount of bacteria. It is possible to forget about the bacteria in that water because of the fact that the softening process accomplishes the removal of all bacteria when the softening reactions are carried through properly. The Ironton plant mentioned this morning has recently adopted the lime treatment in the double coagulation system to accomplish the elimination of bacteria during times of excessive load.

Another point is in regard to the elimination of material precipitated in the process of water softening. As you understand the softening reactions create a rather heavy precipitate. It is necessary to remove that precipitate and it is desirable to remove it continuously rather than to store it up over a period of time. Experience at Columbus demonstrates this fact. The Newark plant installed in 1924 was the first one in our state to utilize the principle of continuous withdrawal of sludge in a clarifier. It has been successful in the disposal of the calcium carbonate sludge into a small stream.

The final point I want to comment upon is in regard to the argument between the designing and practicing engineers as to what is the best type of clarifier, and the best means of introducing the flow and taking it from the clarifier to obtain the best results. Some of the arguments are in favor of the rectangular design and some are in favor of the circular. Of course, the multiplicity of means by which you can get the water into the clarifier and out of it is evident. However, there seem to be two well recognized points. First the water must be properly treated to create a flocculent precipitate, and the softening reactions must be completed and second there should be proper distribution of flow into and out of the clarifier. It may be that size or shape are not material factors, but certainly distribution into the clarifier and displacement through the clarifier are important.

RESERVOIR COVERING PAYS DIVIDENDS[1]

By C. W. Klassen[2] and H. F. Ferguson[3]

The Edwardsville Water Company, which furnishes the public water supply for Edwardsville, recently covered an open storage reservoir at the suggestion of the Division of Engineering of the State Department of Public Health and thereby made a net annual saving of $61.50. This is a small saving, but it is a saving and the cleaner, safer and otherwise improved quality of the supply and resulting satisfaction among consumers, represents a value to the company far exceeding the cash saving.

The Edwardsville supply is pumped from wells into a concrete collecting or storage reservoir. The reservoir, 70 feet square at the top, has hopper sloped sides, is 40 feet square at the bottom, 10 feet deep and has a capacity of 250,000 gallons. A wall through the center permits cleaning of one half at a time.

Before the reservoir was covered, a luxuriant growth of algae necessitated cleaning it twice monthly. Copper sulphate treatment suggested by us was partially successful, but the algae growth was still sufficient to impart objectionable tastes which were often complained of by the consumers. The treatment too was somewhat of a nuisance. The uncovered reservoir also subjected the entire public supply to contamination by dust, dirt, insects, animal pollution, etc., and contamination introduced by workmen during the frequent cleanings. The cleaning operations not only introduced contamination, but also caused inconvenience and interruptions of operation and, because of reduced storage, a fire hazard.

Figures covering several years operation with the open reservoir show that approximately $175.00 were spent annually trying to keep the reservoir clear and free from algae growths. This figure includes the labor and copper sulphate treatment.

[1] Presented before the Illinois Section meeting, March 29, 1928.

[2] Assistant Engineer, Division of Sanitary Engineering, State Department of Public Health, Springfield, Ill.

[3] Chief Engineer, Division of Sanitary Engineering, State Department of Public Health, Springfield, Ill.

For several years the Engineering Division of the State Department of Public Health recommended that the reservoir be covered. Following a change in ownership, this improvement was made in May, 1927. The cover is a tight substantial plank and tar paper roof supported on a steel frame, erected at a total cost of $1500.00.

Two financial comparisons of the reservoir covered and uncovered will be made, (1) by comparing the *total capitalized cost* in each case and (2) by comparing the *annual expense* before and after covering.

Total capitalized cost comparison. The cost in terms of capital is equal to the first cost, plus the annual cost of operation and maintenance capitalized at the current rate of interest, plus the capital necessary to add to make good the depreciation, that is to provide a sum which when put at the current rate of interest will be sufficient to renew the structure at the expiration of its life. Expressed as in "Public Water Supplies," by Turneaure and Russel:

$$S = C + \frac{0}{r} + \frac{C}{(1+r)^n - 1}$$

where S = total capitalized cost
C = first cost of cover
0 = annual cost of operation and maintenance
r = current rate of interest
n = life of structure

With the reservoir *uncovered* C (first cost of cover) and $\frac{C}{(1+r)^n - 1}$ (capital necessary for depreciation) are zero and only the operating cost of $175.00 for cleaning need be considered. Taking the current rate of interest as 5 per cent in all calculations, the total capitalized cost is $S = 0 + \frac{175}{0.05} + 0 = \$3500.00$.

With the reservoir *covered* C is $1500.00, the operating cost zero and the depreciation item (for cover only) is divided into three parts, namely, the depreciation on (1) the roofing material, (2) the plank roof and (3) the steel frame. It was assumed that the tar roofing paper would be replaced every 10 years at a cost of $200.00, the plank roof every 20 years at $500.00 and the structure (including the tar paper and plank) every 50 years at $1500.00. It was also assumed that the reservoir would be cleaned every 10 years at a cost of $10.00. This amount not being an annual maintenance expense should be included in "depreciation" because it is necessary to maintain enough

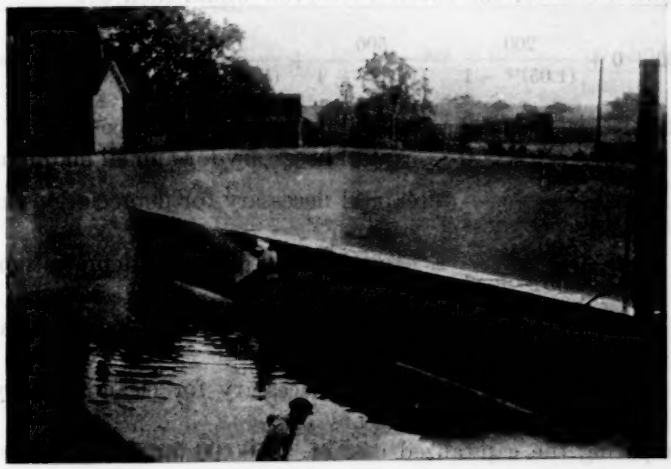

FIG. 1. BEFORE RESERVOIR WAS COVERED

FIG. 2. AFTER RESERVOIR WAS COVERED

capital to care for the $10.00 expense every 10 years. The total capitalized cost for the covered reservoir would then be:

$$S = 1500 + 0 + \frac{200}{(1.05)^{10} - 1} + \frac{500}{(1.05)^{20} - 1} + \frac{1500}{(1.05)^{50} - 1} + \frac{10}{(1.05)^{10} - 1} = \$2270$$

where
$$1500 = \text{capital necessary for first cost}$$
$$0 = \text{capital necessary for annual maintenance}$$
$$\frac{200}{(1 + 0.05)^{10} - 1} = \text{capital necessary for depreciation on tar paper}$$
$$\frac{500}{(1 + 0.05)^{20} - 1} = \text{capital necessary for depreciation on plank roof}$$
$$\frac{1500}{(1 + 0.05)^{50} - 1} = \text{capital necessary for depreciation on steel frame}$$
$$\frac{10}{(1 + 0.05)^{10} - 1} = \text{capital necessary for cleaning every 10 years}$$

Comparing the capitalized cost of $3500.00 for the reservoir uncovered to the $2270.00 covered, a capital saving of $1230.00 is obtained. This amount at 5 per cent interest, gives an annual saving of $61.50 with the reservoir covered.

Annual expense comparison. The annual expense of the uncovered and covered reservoir by this method is equal to the sum of (1) the interest on the first cost, (2) the annual cost of operation and (3) the annual depreciation or the annual payment necessary if placed at compound interest to accumulate in the life of the structure an amount equal to the cost for renewal or:

$$\text{Annual expense} = C\,r + 0 + \frac{C\,r}{(1 + r)^n - 1}$$

where C = first cost of cover
r = rate of interest
0 = operating expense
n = life of structure

The annual expense of the *uncovered* reservoir is simply the annual operating expense of $175.00, for there is no first cost and hence no depreciation of cover.

The anual expense of the *covered* reservoir is (1) the first cost $1500.00 times the rate of interest 5 per cent, plus (2) the operating expense which is zero, plus (3) the annual depreciation which is taken

in three parts, as in the capitalized cost method, plus (4) the expense of cleaning every 10 years.

$$\text{Annual expense} = 1500 \times 0.05 + 0 + \frac{200 \times 0.05}{(1.05)^{10} - 1} + \frac{500 \times 0.05}{(1.05)^{20} - 1}$$

$$+ \frac{1500 \times 0.05}{(1.05)^{50} - 1} + \frac{10 \times 0.05}{(1.05)^{10} - 1} = \$113.50$$

where 1500×0.05 = first cost of cover × annual rate of interest

0 = annual operating cost

$\frac{200 \times 0.05}{(1.05)^{10} - 1}$ = annual depreciation on tar paper life 10 years

$\frac{500 \times 0.05}{(1.05)^{20} - 1}$ = annual depreciation on plank roof life 20 years

$\frac{1500 \times 0.05}{(1.05)^{50} - 1}$ = annual depreciation on steel frame life 50 years

TABLE 1

	BEFORE COVERING			AFTER COVERING		
	From wells	From reservoir and distribution systems	Last nine samples	From wells	From reservoir and distribution systems	First nine samples
Number of 10-cc. portions analyzed	217	6,052	45	5	198	45
Per cent positive	1	21	13	0	6	7
Average bacterial count per c. c.	11	129	19	2	76	22

Comparing the annual cost of $175.00 without cover to $113.50 with cover, an annual saving of $61.50 is obtained, which corresponds to the saving figured by the capitalized cost method.

All persons interested in supplying water to the public realize the value of a clear, clean water free from objectionable odors, tastes and possibilities of pollution. According to A. P. Harris, manager of the water company, no complaints regarding objectionable tastes or odors have been received and no algae noticed since the reservoir was covered.

Analyses of samples collected before and after the covering of reservoir also show the improvement made by the cover. These analyses are shown in table 1.

The wells both before and after the covering of the reservoir yielded a water which conformed to the United States Public Health Service standards, but exposure in the open reservoir changed the quality so as to bring it outside these standards, which allow 10 per cent of the 10 cc. portions analyzed to be positive (and formerly a bacterial count of 100 per cubic centimeter). The limited number of samples (9) analyzed since the reservoir was covered show that the tap water now meets the United States Public Health Service standards.

Thus an investment $1500.00 in the reservoir cover resulted in:

1. Decreased inconvenience and interruption of operation.
2. Decreased fire hazard.
3. Prevention of objectionable odors and tastes.
4. Prevention of dangerous and other contamination.
5. Approval of the supply by the United States Public Health Service for use on interstate carriers.
6. Annual net saving of $61.50. This is not a large amount, but it is more pleasant for a water superintendent to report a saving than a loss to his company or governing committee.
7. Last and not least in the thoughts of waterworks men a "dividend" consisting of friendly water consumers who are the source of all water revenue and thus the dividends.

MANGANESE IN THE CROTON WATER OF NEW YORK CITY

By Frank E. Hale[1]

In the middle of September, 1925, numerous complaints were received from the Harlem section of Manhattan, New York City, of dirty water and in some instances of bad taste. The former were caused by a reddish-brown floc and the latter by a musty flavor accompanying the floc. It was at first thought that the trouble was due to local disturbances of sediment in the mains, particularly since on September 2 three 48-inch pipe lines conveying new aqueduct Croton water from 135th Street gatehouse to Central Park reservoir were shut off and the water added to the water passing through the old aqueduct to this reservoir. The sediment had the appearance of pipe rust and the matter was not called to the attention of the Laboratory Division for a week or more when it was seen that the trouble persisted. Examination of daily samples taken from the aqueducts between Croton Lake and the City did not disclose any abnormal turbidity figures. It seemed certain that the trouble was local until about a week later when the writer noted that the above aqueduct samples on standing had developed the same reddish-brown floc seen in the complaint samples. This observation indicated that the trouble was really coming from Croton Lake. Considerable study was necessary to ferret out the cause as well as the control.

In addition to the ordinary complaints, laundries complained of the spotting of clothes by the setting of the bluing. Although reddish-brown in color while wet, the floc had a suspiciously dark, almost black, appearance when dry. Chemical analysis of the floc showed that it contained a large amount of manganese, which undoubtedly accounts for the laundry complaints, like similar experiences at Baltimore, Md. (Baylis, Jour. Am. W. W. Assoc., vol. 12, October, 1924, pages 211–233) and McKees Rocks, Pa., (Kneeland, Jour. Am. W. W. Assoc., vol. 13, April, 1925, pages 436–438), due to manganese. The analysis, although made on a few milligrams, was carried through

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by the regular methods of mineral analysis, separation of iron by basic acetate method and precipitation of the brown manganese dioxide by bromine. Qualitative tests were clean-cut. Fusion of some of the floc with sodium carbonate and a bit of potassium nitrate gave a beautiful robin's egg blue. Also in the test for copper, during electrolysis a deep permanganate color developed due to manganese. Quantitative results were:

	per cent
Manganese dioxide	23
Iron oxide	9
Copper	0
Alumina and silica (chiefly former)	28
Loss on ignition (probably 28 per cent water of composition and 12 per cent organic matter)	40
	100

Coincident with the appearance of the manganese floc and the complaints, the orthotolidin reaction in the Croton water previous to chlorination at Dunwoodie on the aqueduct increased sharply from an average of 0.07 to 0.32 p.p.m., expressed as chlorine, and reached a maximum of 0.35 p.p.m. The sharp increase was from September 12 to 17, the maximum from September 25 to 29. There was then a gradual fluctuating, falling-off until a normal was reached by November 30. The reaction of manganese dioxide with the hydrochloric acid in the orthotolidin reagent would result in formation of free chlorine, which accounts for the color reaction previous to chlorination. The reaction is then probably a quantitative measure of the amount of floc in the water during the entire period. Comparing the maximum orthotolidin reaction, 0.35 p.p.m., and maximum increase, about 0.28 p.p.m., expressed as chlorine, with the analysis of the floc the figures are:

	RESULTS		
	Total	Increase	Normal
	p. p. m.	*p. p. m.*	*p. p. m.*
Manganese	0.27	0.22	0.05
Manganese dioxide	0.43	0.34	0.09
Total floc (dry weight)	1.87	1.48	0.39

Determination by the silver persulphate method of the American Public Health Standards in January, 1926, of the manganese in Croton Lake effluent yielded manganese 0.08 p.p.m., which agrees very well with the above normal figure and also indicates that a large part of the orthotolidin reaction regularly experienced before chlorination in the Croton water is due to manganese dioxide.

At the same time that the orthotolidin reaction increased, the amorphous matter in the microscopic examination of Croton Lake effluent jumped to 5,000 units. The normal is about 700 to 1,500 units. While this determination is crude and subject to wide personal variation, the increase tallies roughly with the increase in orthotolidin reaction. The above figures give some idea of what small amounts of manganese may cause trouble.

THE OCCASION OF THE TROUBLES

Early in September it became necessary to draw down Croton Lake 6 feet in order that the buttresses of the bridges crossing the Lake might be examined in connection with need for repair. This draft was made from bottom water at Croton Dam at 105-foot depth from September 1 to 9 and for the early portion of this period at the rate of roughly 650 m.g.d. Regular draft from Croton Lake is taken at the same general locality at 75-foot depth and amounted to approximately 150 m.g.d. Thus there was a total flow of 800 m.g.d. from the bottom of the lake, which undoubtedly caused the disturbance of material there deposited. Refilling the lake with cold bottom water from the upper reservoirs started on September 10. Unfortunately an unexpected early drop in temperature took place the first week of September resulting in an overturning of the water between September 1 and 8, such that the difference in temperature between the surface water and the water at 75 foot depth was only 6°F. on the 8th against 17°F. on the 1st. This overturning disseminated the reddish-brown floc throughout the mass of water. Repeated drops in air temperature following increase in temperature caused similar overturnings about September 15, 22, and 30, and similarly throughout October and November. This kept the floc in suspension so that it settled very slowly.

Two aqueducts carry the water from Croton Lake to the City. The old aqueduct water comes straight through to the City, but the new aqueduct water normally passes through Jerome Park reservoir (900 m.g.d. capacity), entering at the lower end and leaving near the

center, representing three or more days storage at rate of draft in question. Unfortunately Jerome Park reservoir was out of service (August 24 to September 18) at the beginning of the period of trouble and up to September 18. Hence the floc came straight through to the City, without opportunity for settling. Fall overturnings have never caused such trouble before, although this floc must be the accumulation of years. It must have been the combination of circumstances of drawing water in large volume from the bottom of the lake coincident with overturning which brought up the floc. The small organic content also indicates that it came from the bottom, i.e., a long-standing deposit from which the organic matter

TABLE 1

Manganese in reservoirs

	MANGANESE
	p. p. m.
Boyd's Corner reservoir	0.06
West Branch reservoir	0.06
Middle Branch reservoir	0.08
Bog Brook reservoir	0.06
Sodom reservoir	0.08
East Branch Stream at Croton Falls	0.08
Croton Falls reservoir	0.10
Titicus reservoir	0.03
Cross River reservoir	0.08
Amawalk reservoir	0.03
Muscoot reservoir, Wood's Bridge	0.10
Croton Lake effluent	0.08

had been digested, rather than debris of microscopic organisms. (Treatment of the lake for Aphanizomenon had taken place August 12 to 17 with 4,950 pounds of copper sulphate. For that reason test of the floc for copper was made, which proved negative.)

Analyses were made in January this year for manganese in all the reservoirs contributing to Croton Lake (A. P. H. A. Standard Methods, silver persulphate). These probably represent normal conditions and show that a small amount of manganese is present in all the sources, which accounts for the accumulation in the bottom of Croton Lake. Table 1 contains these figures, arranged from the upper watershed to Croton Lake.

The amorphous matter figures for all samples taken from Croton

Lake and all the tributary reservoirs, top and bottom, were tabulated for the months of September to November. The relative size of the figures and times of occurrence indicate that the trouble was in Croton Lake and at the Dam. The figures in table 2 show this.

Figure 1 shows the relationship between air temperatures in New York City, water temperatures in Croton Lake, orthotolidin reaction of effluent water, and amorphous matter in effluent water during the three months that the floc persisted.

As Croton Lake lies 40 miles to the north there is not an exact coincidence of temperatures probably, but sufficiently close coincidence of change of temperature.

TABLE 2

Amorphous matter in reservoirs

	MILES FROM DAM	MICROSCOPICAL EXAMINATION. AMORPHOUS MATTER, UNITS PER CUBIC CENTIMETER	
		September 8	September 15
Muscoot reservoir, surface	11	1,250	900
Croton Lake, Pine's Bridge, surface	6		1,100
Croton Lake, New Gatehouse, surface	3	550	1,100
Croton Lake, New Gatehouse, bottom	3	650	1,000
Croton Lake Dam, surface	0	550	1,700
Croton Lake Dam, 75 foot depth	0	525	5,000
Croton Lake Effluent, 75 foot depth	0	625	5,000

It is obvious that a profound overturning took place between September 1 and 8, coincident with the heavy bottom draft, and that these overturnings continued bringing the surface and 75 foot temperatures closer and closer and at the same time changing the absolute temperature of both, gradually lowering it from the neighborhood of 70°F. to 50°F. As air temperatures are always fluctuating, one might ask: When does overturning commence? Probably when the smooth curve of average temperature trend begins to fall. But, usually, judging from thermocline studies made of Croton Lake several years ago, the overturning takes place gradually, the effect reaching deeper and deeper until the entire mass goes over. This is obvious in the 1924 temperatures of the following table. The difference in temperature between the surface water and the draft water at

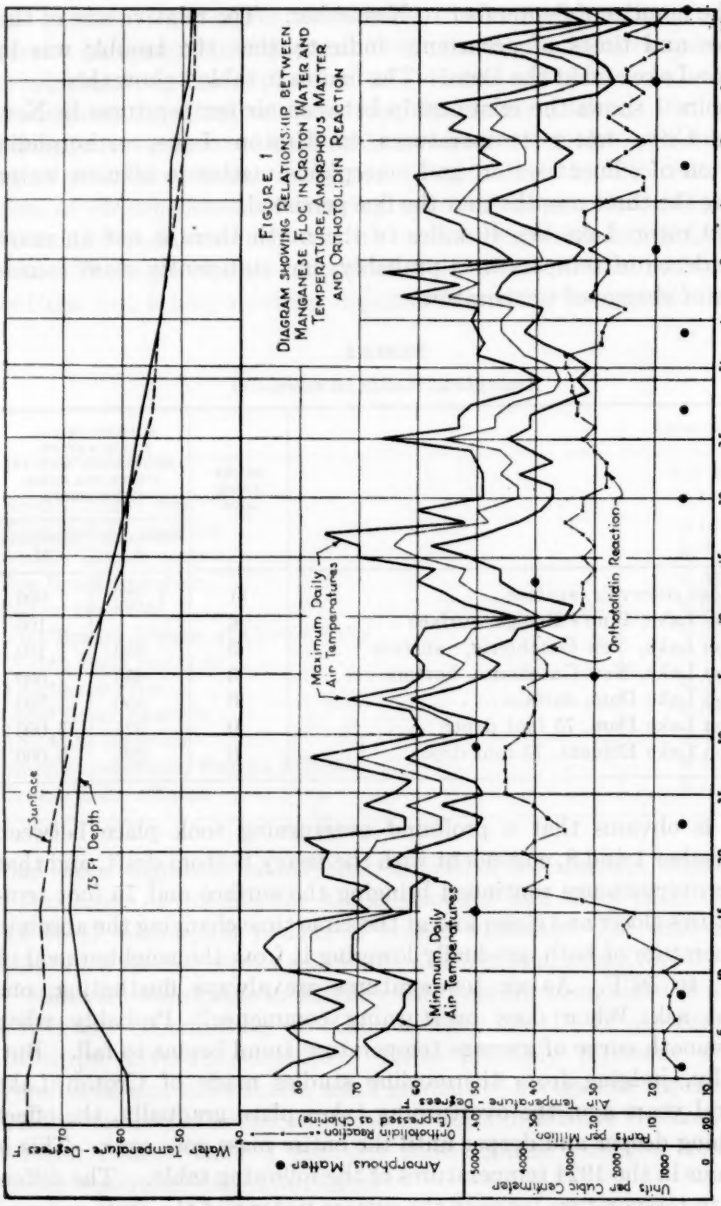
FIGURE 1
DIAGRAM SHOWING RELATIONSHIP BETWEEN MANGANESE FLOC IN CROTON WATER AND TEMPERATURE, AMORPHOUS MATTER AND ORTHOTOLIDIN REACTION
Water Temperature - Degrees F
Surface
75 Ft Depth
Amorphous Matter
Orthotolidin Reaction (Expressed as Chlorine)
Air Temperature - Degrees F
Maximum Daily Air Temperatures
Minimum Daily Air Temperatures
Orthotolidin Reaction
Parts per Million
Units per Cubic Centimeter
September
October
November

FIG. 1

75 foot depth gradually decreased by about 2° each week from 13° to 3° and the temperature at 75 foot depth gradually increased from 62° to 66°. But in 1925 within the first week the temperature at 75 foot depth rose from 59° to 67°, more than within a month's time the previous year. This would seem to indicate definitely that the bottom draft was the predominating cause for the early profound overturning. Pertinent observations are shown in table 3.

The sharp increase in orthotolidin reaction and amorphous matter follows the overturning with a certain lag, indicating that a floating precipitate or floc rather than a solution was being disseminated, since the temperatures were immediately affected. This is mentioned since the floc is not apparent in fresh samples, but collects on standing quietly for several hours, preferably twenty-four hours or more. While there is some similarity to iron precipitating out of colorless

TABLE 3

Temperature changes, 1924 and 1925, Croton Lake

TEMPERATURE, 1924				TEMPERATURE, 1925			
Date	Surface	75 foot depth	Difference	Date	Surface	75 foot depth	Difference
September 2	75°	62°	13°	September 1	76°	59°	17°
September 9	71°	60°	11°	September 8	73°	67°	6°
September 16	72°	63°	9°	September 15	74°	69°	5°
September 23	70°	65°	5°	September 22	72°	68°	4°
September 30	69°	66°	3°	September 29	69°	67°	2°

ground waters and while it is possible that the manganese may be held in solution by excess carbonic acid at the bottom of the lake and floc out on coming to the surface through loss of carbonic acid, it seems more likely that small particles gather slowly together into visible flocs. The orthotolidin reaction curve corresponds exactly with the period and amount of trouble.

The lines of air temperature separate during days of variable temperature and contract at times of little daily change. The latter should have the greater influence on the water. It is surprising how closely some of the orthotolidin changes agree with temperature changes, for example, the sharp increase in orthotolidin reaction, 0.13 to 0.32 p.p.m., on September 15–17 during the three days of unchanging colder temperature. Similarly the colder weather of September 22–26 resulted in a sharp increase of orthotolidin re-

action from 0.25 to 0.35 p.p.m. During October and November the floc was gradually settling with occasional disturbances as shown by the curve of orthotolidin. The amorphous matter corresponds only roughly, but is noticeable when the trouble started and during its height.

SUGGESTED REMEDIES

As New York City has no filter plant in connection with the Croton supply and as one complication leads to another, it may be interesting to comment briefly on the handling of the situation. Consumers who

TABLE 4

Examination of special samples, Croton Lake

	RELATIVE AMOUNT OF FLOC	AMORPHOUS MATTER	ODOR	TOTAL MICRO-ORGANISMS	APHANIZOMENON	SYNURA	UROGLENA
New Dam, surface	1	1,250	1v	575	250		
New Dam 35 foot depth	2	1,790	2v	1,045	325		
New Dam 75 foot depth	3	2,450	1v	965	350		
New Dam 100 foot depth	4	3,650	1m	1,200	525		
2 miles above Dam, surface	1	1,200	1v	705	250		
Old Dam, surface, (3 miles)	2	1,350	1v	780	325	1	
Old Dam, 30 foot depth	2	1,250	1v	1,110	325		
Old Dam, 60 foot depth	3	1,750	2v	1,305	575	10	
Pine's Bridge, surface (6 miles)	1	1,150	1m	1,505	400	6	100

(Only important forms receiving consideration included: Dictyosphaerium Dinobryon, Asterionella, Synedra, Tabellaria, and Melosira were also present but in too small amounts to be considered.)

were troubled were instructed to use cloth filters on their service taps with daily cleansing until the trouble should end. Jerome Park reservoir was turned into service on September 18 and was half on by the 24th and fully on probably by the last of the month. (It was put into service slowly owing to previous complaints of taste and odor following treatment for Asterionella.) This provided sedimentation for the floc in the new aqueduct water. The old aqueduct was shut down October 1 from Croton Lake to Jerome Park reservoir and on October 14 from Jerome Park reservoir to 135th Street gatehouse. After this, practically no further complaints were

received, as no water was received in the City without sedimentation in Jerome Park reservoir.

Meantime on October 1 inspection was made of Croton Lake and samples taken by two-bottle method at different depths and at different points, since draft may be taken at different depths at the new dam or three miles up-lake at the new aqueduct gatehouse, site of the old dam. The results of examination of these samples are shown in table 4.

It was immediately seen that the floc increased with depth. Draft could not be shifted to surface owing to mechanical difficulties. Hence on October 3 draft was shifted to 35 foot depth at the new dam. It was inadvisable to shift to the old dam on account of Synura, though small in amount. It also was advisable to clean up the Synura as draft was shifted nearer to the surface at the new dam and Synura prefers the upper water. Consequently treatment with copper sulphate, 5,960 pounds, 1 pound per million gallons capacity, was made October 2 to 6 from just below the old dam to Muscoot dam. Owing to Synura, Uroglena and Aphanizomenon continuous treatment at Muscoot dam was started by suspended buckets, with a hole in the bottom, at the rate of 1 pound per millions gallons flow. Fourteen weighted buckets were suspended at intervals from a wire strung across the lake just below the submerged Muscoot dam. Copper sulphate was added to the buckets each day and the amount dissolved regulated by the depth to which the buckets were submerged. This treatment was continuous from October 2 to 31, using 3,000 pounds of copper sulphate.

Despite the precautions taken, probably due to a section of flow which escaped treatment, Aphanizomenon increased in the aqueduct water October 3 and reached 1500 units a little later. To control this growth the chlorine was increased to 0.72 p.p.m. dosage, 0.22 residual. (Similar experience in the spring had shown that maintaining 0.22 p.p.m. [0.20–0.25] residual, 0.83 p.p.m. dosage, had reduced 1500 units of Aphanizomenon by 50 per cent at least, after passage through Jerome Park reservoir and prevented seeding Central Park reservoir with any Aphanizomenon.) Synura appeared once only during this period in the aqueduct and was taken care of by the chlorine. The higher chlorine dosage also helped to destroy the musty flavor and probably assisted complete flocculing of the manganese, facilitating its settling in Jerome Park reservoir. For this reason it was continued after the amount of Aphanizomenon had decreased again.

The dosage was maintained at 0.72 p.p.m. from October 9 through November 9, when it was decreased to 0.60 p.p.m., residual between 0.15 to 0.20 p.p.m., owing to slight chlorine taste in the chlorinated water, due to the fact that the water was colder or absorption less. The dose was not reduced to normal until December 8 when it was sure that the water was normal again.

Similar trouble has been noted each fall since then evidently due to regular fall overturning, but not nearly so extensive as was caused that particular year by the blowing off of water from the bottom of the Lake. It is evidently a yearly occurrence, but of much less severity.

APPELLATE DIVISION AFFIRMS TYPHOID FEVER DAMAGE AWARDS AGAINST ALBANY, N. Y.

By Charles R. Cox[1]

The Appellate Division of the Supreme Court of New York State has unanimously affirmed the action of a supreme court jury which in November, 1926, awarded $2,000 to a minor and $1,000 to his father on the claim that the patient contracted typhoid fever from the drinking water of the city of Albany, in April, 1924.

The water supply of the City of Albany is secured from the Hudson River at a point about 8,000 feet north of the main portion of the city. An elaborate water purification plant is utilized to treat the heavily polluted Hudson River Water. This plant consists of aerators, coagulation basins, rapid sand filters, secondary aerators, slow sand filters and chlorination equipment. The chlorinated water from the clear well flows to a high pressure pumping station about 8,000 feet south of the filtration plant through a conduit.

The filtration plant is under expert supervision and water of a safe sanitary quality has been discharged into the clear well. The conduit conducting the effluent from this clear well to the high pressure pumping station, however, consists of about 8,000 feet of steel piping 48 inches in diameter, most of which is covered with concrete. The steel conduit had been in use for over twenty years and the walls had become seriously corroded at points. This conduit is laid for the most part under the bed of the abandoned Erie Canal, which normally contains about 1 foot of water due to local drainage. In April, 1924, a flood of the Mohawk and Hudson Rivers occurred and the abandoned Erie Cana[1] was flooded to a depth of from 6 to 8 feet with polluted Mohawk River water.

During April, 1924, there was a sudden increase in the prevalence of typhoid fever in the city of Albany, and during this period the tap water in the city contained increasing numbers of colon bacilli, as determined by bacteriological examination in the State Laboratory.

[1] Assistant Sanitarian, Division of Sanitation, State Department of Health, Albany, N. Y.

Suit was brought against the city of Albany by the parent of one of the patients who contracted typhoid fever at this time. A decision in favor of the plaintiff was handed down by the Supreme Court in 1926, which decision was appealed to the Appellate Division of the Supreme Court in May, 1928. The important portions of the opinion of the presiding justice of the Appellate Division are quoted below:

It is claimed that the disease had its inception in unwholesome water furnished by the city, and this condition arose through the negligence of those in charge of the water system in failing to purify the water delivered to consumers; and that the authorities neglected to give warning, although they had notice that dangers existed. . . . .

Beginning on April 7, the water was tested at the state laboratory by and under the supervision of Dr. Wachter, a chemist in the Division of Laboratories and Research of the State Department of Health. These tests were made from the tap which was on the same system as that furnishing water to plaintiff's family. On nearly every day between the 7th and the 23d of April, colon bacilli were found in increasing numbers, indicating some definite source of pollution not eliminated by the filtration. About this time there was a sudden increase in gastro-intestinal diseases in the city. The officials in charge of the water department had notice of the defective condition of the conduit, the sudden pollution of the water, and of the outbreak of diseases traceable to impure water, but the warnings were ignored. It was a time for prompt and decisive action. There were two possible sources of contamination—one by impure water passing the filters into the well; the other by introduction of polluted water into the conduit. The exercise of vigilance would have led to discovery of the dangerous condition, and reasonable diligence would have provided the remedy. It was possible by greater chlorination before the water went into the clear water well, to eliminate all dangerous bacilli which had passed the filter; and there was a chlorination plant at the Quackenbush street pumping station which would have removed the new pollution occurring in the conduit, but this was not put in use, at least during the first ten days in April. Common prudence would have suggested a notice to citizens that the water had become polluted, and a recommendation that all water intended for human consumption should be boiled. But no preventive measures were taken until an epidemic had broken out. . . . .

To insist that the plaintiff must establish that the infection came from the city water by positive proof, would be to require an impossibility. It is sufficient if it is shown by the best evidence available that the bacilli were introduced into his system by means of the city water, so that the jury may by reasonable inference reach a conclusion to that effect. This is not speculation, but a process of logical deduction. . . . .

The plaintiff gave proof excluding other sources of infection. The defendant's counsel in argument merely suggests that there are other possible sources, but there was no sufficient proof on its part of their presence or of the probability that such causes intervened to furnish the origin of the plaintiff's

disease. The epidemic at this particular time, including such a large number of cases, would under the circumstances shown, indicate a common origin. . . . .

Particular attention is called to the next to the last paragraph above, since it is not unusual in cases of this kind for attorneys for the defense to attempt to make the plaintiff furnish positive proof that the infection came from the water, which, as the court justly says, is an impossibility.

Since this outbreak of typhoid fever, great care has been exercised in maintaining 0.20 to 0.25 p.p.m. residual chlorine in the tap water in the city about $\frac{3}{4}$-mile from the point of application, although this practice has naturally resulted in the delivery of water with a chlorine taste at frequent intervals. The city authorities have installed a booster pumping station at the filtration plant, which places the repaired conduit under a positive pressure at all times, so that any appreciable leakage would be of filtered water outward rather than polluted surface water inward. The water passing through the conduit is again chlorinated at the high pressure pumping station.

The steel conduit is being replaced by cast iron pipe at considerable expense. This pipe line will be used until the new water supply from the Catskill Mountains is completed, which will permit the abandonment of the Hudson River supply, and the use of the cast iron pipe as a main feeder for the northern portion of the city of Albany.

THE FOTOTURBIDIMETER IN THE DETERMINATION OF WATER TURBIDITY

By Atilio A. Bado[1] and Rogelio A. Trelles[2]

In 1916, we published in "Anales de la Sociedad Química Argentina" a discussion of the various methods proposed at that time for the determination of the turbidity of waters, and we proposed the use of the "Fototurbidimeter."

Notwithstanding our interest in the new methods which have been proposed till now, we still know of none which can replace it advantageously.

The apparatus and method have been officially adopted by the Laboratorio de Obras Sanitarias de la Nación (National Sanitary Works Laboratory) Argentine Republic, for more than twelve years. The results have been very satisfactory.

The basis of the method is the relative absorbing effect of muddy water on the light rays passing through it.

Its two bands of light rays of equal intensity are allowed to pass through two glass containers of equal size, one containing the standard water and the other the water whose turbidity must be found, the intensities of the rays after passing through the containers will be inversely proportional to the respective water turbidities.

In determining the index of turbidity with the use of the fototurbidimeter we compare natural water with the same water after filtering it through a candle filter to eliminate the suspended matter.

The apparatus is provided with two iron rails 3 meters long supported on iron legs at 1.20 meters in height (figure 1). On the front rail a scale is engraved, the zero of it being in the middle of the rail. From the zero point to the rail ends, series of 0.5 cm. marks are made which serve to determine the position of the Bunsen Fotometer supported by a little car which slides upon the rails and to which an index is attached. At the rail ends two small size electric lamps are

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[2] Chemist, Laboratory, Obras Sanitarias de la Nación, Buenos Aires, Argentine Republic, South America.

fixed covered with brass cases which are blackened on the interior and have an open side. The electric current is provided by a 4 to 6 volts accumulator and its intensity can be varied by means of two rheostats connected between the accumulator and the lamps. The light intensities of both lamps are adjusted to that of the Hefner's unit, obtaining thus equal intensities. After this adjustment the fotometer, if located at the zero point, must show that equivalence.

Between the lamps and the fotometer, at 30 cm. from the former, two crystal cubes are set up with perfectly parallel walls. The form and size of these cubes are illustrated by the following measurements (interior): height, 14 cm.; width, 8 cm.; length, 14 cm. The crystal used is 3 mm. thick. In each cube the wall looking to the fotometer is entirely blackened with the exception of a circle 5 cm. in diameter,

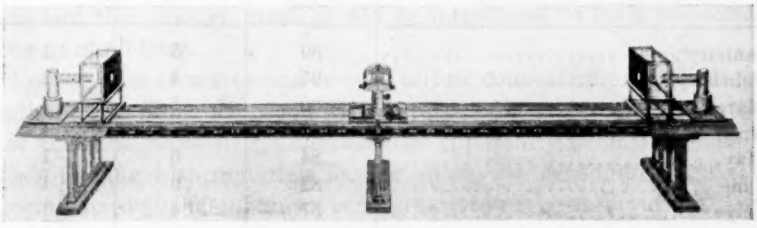

FIG. 1. THE FOTOTURBIDIMETER

whose center is situated at the height of those of the lamps and consequently of those of the circular openings of the fotometer.

In operation the containers are moved off and then the lights are tested to verify their intensity equivalence. After this test the containers are filled one with the natural water and the other with the same water after filtering it through a candle filter. The one containing natural water is set up in its previous position on the rails at the left of the fotometer and that with filtered water at the right. The muddy water is stirred now and then to maintain the insoluble matters in suspension.

The lights are turned on. The muddy water will absorb some of the light rays, producing thus a reduction of the intensity of the light reaching the fotometer, consequently breaking the equilibrium of the lights existing before the full containers were in place. The fotometer grease spot will be illuminated on its left side and dark on the right side. By sliding the fotometer to the left a point will be reached

where the grease spot will disappear entirely, indicating that the light intensities are equal at both sides of the grease spot.

Practically it is more accurate to observe only the grease spot as it is reproduced in the mirror corresponding in the fotometer to the side where the filtered water container stands. When it just disappears from there the new equilibrium point is reached, and that point is read on the scale and recorded as the index of turbidity or the tested water.

All determinations are made in a dark room.

TABLE 1

Index of turbidity by fototurbidimeter (monthly averages)

1926	RAW RIVER WATER (RIO DE LA PLATA)	SETTLING BASINS	FILTER EFFLUENT
January	89	5	1
February	95	4	1
March	80	5	1
April	88	12	1
May	84	6	1
June	82	9	1
July	57	4	1
August	88	9	1
September	56	6	1
October	71	6	1
November	65	5	1
December	69	5	1

In making several determinations on the same sample readings are obtained which vary from 1 to 2 cm., which is a negligible difference in this class of tests.

The apparatus shows directly turbidities up to 100. In testing muddier waters, the sample is diluted with the same water after filtration or with a very limpid water, the respective correction factor being determined each time.

Generally the filtered water turbidity index is below 1; when it is 2 or more a deficiency in the filter plant must be looked for.

The turbidity of the raw river water of the Río de la Plata varies according to the conditions of the river.

In table 1 record is made of the index of turbidity of Buenos Aires city waters (raw river water, coagulated water and filter effluent.)

THE OXYGEN CONSUMED DETERMINATION[1]

By Geo. W. Burke[2]

Official methods give the details of the method of determining oxygen consumed as follows: To 100 cc. of water, or a smaller amount diluted to 100 cc., add 10 cc. of $\frac{1}{3}$ H_2SO_4 and 10 cc. of $KMnO_4$ solution. Digest in boiling water thirty minutes, add 10 cc. of ammonium oxalate solution and titrate with $KMnO_4$. If 10 cc. of $KMnO_4$ is insufficient try again using a larger amount. Methods written in some books advise that if the $KMnO_4$ first added is insufficient that enough more should be introduced to keep an excess present at all time.

For samples of water and sewage of low concentration, the above method will probably prove satisfactory with the exception of the fact that the *blank* determination has apparently been overlooked. When dealing with materials having an oxygen consuming capacity ranging up to 10,000 p.p.m., it is necessary to make observations that are not above considered.

FACTORS CAUSING VARIABLE RESULTS

In dealing with this determination in connection with some industrial wastes, it has been found that a great variety of results could be obtained on the same sample. Individual results can be duplicated, but due to the many possibilities it is desirable to know which result should be selected and as to how relative values on other samples of relative strength could be obtained. An example of the possibilities of the variety of results that could be obtained in the same material is given in table 1.

These data indicate that a wide range of values can be obtained, any of which could be duplicated by running in the same manner. Two analysts working in the same laboratory could obtain values on the same sample which would differ by a great percentage, yet

[1] Presented before the Iowa Section meeting, September 29, 1927.

[2] Chemical Engineer, Engineering Experiment Station, Iowa State College, Ames, Ia.

due to the fact that they were able to check their own results they would each be satisfied.

A relationship exists between the concentration of the oxidizer and the amount of the sample. The strength of the oxidizer is also dependent upon the total volume of solution (whether 10, 25, 50, etc., of $KMnO_4$ present with 100 cc. of sample and dilution water).

TABLE 1

Results due to various amounts of sample

SAMPLE	OXYGEN CONSUMED	$KMnO_4$ USED
cc.	*p.p.m.*	*per cent*
0.25	1,200	12.0
0.50	940	18.8
0.75	867	26.0
1.00	830	33.2
1.50	720	43.6
2.00	640	51.2
3.00	567	68.2
4.00	493	78.8
5.00	440	88.0

TABLE 2

Depletion of $KMnO_4$ due to digestion

WATER	$KMnO_4$	OXALATE	$KMnO_4$ cc TO DEPLETION
cc.	*cc.*	*cc.*	
0	25	25	8.90
25	25	25	2.95
50	25	25	1.80
75	25	25	1.50
100	25	25	1.50
150	25	25	1.50
200	25	25	1.50

To establish the volume on a basis such that the ratio of the oxidizer to the total volume would be the same, a total volume of 135 cc. was decided upon for reasons later brought out. The 135 cc. was made up as follows: 100 cc. of sample and dilution water, 10 cc. of $\frac{1}{3}$ H_2SO_4 and 25 cc. of $KMnO_4$ solution. Using this 100–10–25 proportion, the concentration of the $KMnO_4$ would be constant and therefore comparative in all determinations.

BLANK DETERMINATION

It has been observed that there is always a consumption of $KMnO_4$ due to the volume of the solutions employed, and the method of

TABLE 3

Effect of varying amounts of $KMnO_4$

WATER	$KMnO_4$	OXALATE	$KMnO_4$ = TO DEPLETION
cc.	*cc.*	*cc.*	
100	10	10	1.1
100	20	20	1.3
100	25	25	1.45
100	30	30	1.50
100	40	40	1.60
100	50	50	1.80

TABLE 4

Effect of amount of sample used

NUMBER	TOTAL SOLIDS	SAMPLE USED	$KMnO_4$ USED	OXYGEN CONSUMED
		cc.	*cc.*	*p.p.m.*
1	6,868	1.00		
	6,868	0.50	15.4	3,080
	6,868	0.25	9.4	3,760
2	5,392	2.50	16.4	656
	5,392	1.00	8.3	830
	5,392	0.50	4.7	940
	5,392	0.25	3.0	1,200
3	14,748	0.50	25.8	4,560
	14,748	0.25	16.4	6,560
4	8,932	0.50	18.4	3,680
	8,932	0.25	10.6	4,240
5	3,272	1.00	3.0	300
	3,272	2.50	5.5	220
	3,272	5.00	9.1	182
	3,272	10.00	16.4	164

carrying out the determination. This was always found to be true even in the absence of any sample. To prove this, distilled water

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25	25	25	2.95
50	25	25	1.80
75	25	25	1.50
100	25	25	1.50
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To establish the volume on a basis such that the ratio of the oxidizer to the total volume would be the same, a total volume of 135 cc. was decided upon for reasons later brought out. The 135 cc. was made up as follows: 100 cc. of sample and dilution water, 10 cc. of $\frac{1}{3}$ H_2SO_4 and 25 cc. of $KMnO_4$ solution. Using this 100–10–25 proportion, the concentration of the $KMnO_4$ would be constant and therefore comparative in all determinations.

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100	25	25	1.45
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100	40	40	1.60
100	50	50	1.80

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	6,868	0.25	9.4	3,760
2	5,392	2.50	16.4	656
	5,392	1.00	8.3	830
	5,392	0.50	4.7	940
	5,392	0.25	3.0	1,200
3	14,748	0.50	25.8	4,560
	14,748	0.25	16.4	6,560
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	8,932	0.25	10.6	4,240
5	3,272	1.00	3.0	300
	3,272	2.50	5.5	220
	3,272	5.00	9.1	182
	3,272	10.00	16.4	164

carrying out the determination. This was always found to be true even in the absence of any sample. To prove this, distilled water

was refluxed with H_2SO_4 and $KMnO_4$ and redistilled. In view of such treatment, it is logical to assume that water so prepared would not have an oxygen consuming capacity. The oxalate and $KMnO_4$ solutions were standardized as later described and were exactly equivalent. In the presence of no sample the $KMnO_4$ was depleted as shown in table 2.

TABLE 5

Values using 1 per cent solution

DILUTION	SAMPLE	H_2O	$KMnO_4$	$KMnO_4$ USED	$KMnO_4$ LESS BLANK	OXYGEN CONSUMED*	OXYGEN CONSUMED
cc.	*cc.*	*cc.*	*cc.*	*per cent*			
10	1	90	6.65	26.6	5.35	665	535
20	2	80	12.05	48.2	10.75	603	537
30	3	70	16.15	64.6	14.85	538	495
40	4	60	19.20	76.8	17.90	480	448
50	5	50	21.50	86.0	20.20	430	404
60	6	40	24.00	96.0	22.70	400	378
70	7	30	25.00	100.0	23.70	357	339
80	8	20					
Blank		100	1.3				

* Not considering blank.

TABLE 6

Values using 2 per cent solution

DILUTION	SAMPLE	H_2O	$KMnO_4$	$KMnO_4$ USED	$KMnO_4$ LESS BLANK	OXYGEN CONSUMED*	OXYGEN CONSUMED
cc.	*cc.*	*cc.*	*cc.*	*per cent*			
10	0.5	90	6.40	25.6	5.10	1,280	1,020
20	1.0	80	11.65	46.6	10.35	1,165	1,035
30	1.5	70	15.50	62.0	14.20	1,033	947
40	2.0	60	18.90	75.6	17.60	945	880
50	2.5	50	21.50	86.0	20.20	860	808
Blank		100	1.30				

* Not considering blank.

These data indicate that 135 cc. made up of 100 cc., H_2O, 25 cc. $KMnO_4$, and 10 cc. H_2SO_4 and digested thirty minutes was responsible for a minimum $KMnO_4$ depletion. This being true, it seems that such a proportion of reagents was a logical one to use.

Using a constant volume of water and varying the amount of $KMnO_4$ the values in table 3 were obtained.

These data demonstrate that the $KMnO_4$ destroyed is dependent upon its concentration.

From tables 2 and 3 it is apparent that the 100–10–25 cc. proportion is a logical one to use. If less than 25 cc. $KMnO_4$ were used the range of the solution would be low and if amounts above 25 cc. were employed excessive blanks would be encountered.

From the data in tables 1, 2, and 3, it is apparent that, in dealing with concentrated wastes, large errors would be made if the official methods were followed. (See tables 5 and 6.)

TABLE 7

Comparison of oxygen consumed values for like $KMnO_4$ consumption

SOLUTION	$KMnO_4$ USED	OXYGEN CONSUMED	1 PER CENT TIMES TWO	2 PER CENT
per cent	*per cent*	*p.p.m.*		
1	26.6	535	1,070	
2	25.6	1,020		1,020
1	48.2	537	1,074	
2	46.6	1,035		1,035
1	64.6	495	990	
2	62.0	947		947
1	76.8	448	896	
2	75.6	880		880
1	86.0	404	808	
2	86.0	808		808

The above illustrations in table 4 show the possibilities of different results using the 100–10–25 ratio. The results obtained are dependent on the amount of sample used. In order to obtain comparative and concordant results, one more factor must be introduced, namely, the size of the sample. Small samples give high values and it will be observed that the $KMnO_4$ consumption is small. This is an example of a relatively large amount of $KMnO_4$ (active agent) reacting on a small amount of sample. According to the mass law, reaction under such conditions should proceed rapidly. On the other hand, when we deal with such a sample that consumes most of the $KMnO_4$ the above is not true. Under such conditions, in order to obtain comparative results, such an amount of sample should be employed as would

cause a $KMnO_4$ consumption between fixed limits. A solution was made up by dissolving 1 gram of skim milk powder in 100 cc. H_2O. Samples as indicated in table 5 were run to get a series of $KMnO_4$ consumption values.

The variation of results was not as great as in previous tables. The milk powder used in making the solution was nearly all soluble, which, of course, put it in such condition that it oxidized with the least resistance. For this reason, such a great variation in results were not obtained due to the changes in amounts of sample. However, changes did occur and the results will serve the purpose in view.

The solution used in table 6 was twice as strong as that used in table 5. Ordinarily it would be thought that the values obtained in the second case would be twice as great as those of the first. It is possible using the extremes to get a value of 808 p.p.m. for the 2 per cent solution and a value of 535 p.p.m. for the 1 per cent solution, which is by no means 50 per cent of the 808 value. Reviewing the results it is seen that, where corresponding amounts of $KMnO_4$ were consumed, the results are relative to the strength of the solutions. Table 7 illustrates this point.

These data indicate that, where the amount of $KMnO_4$ used is similar, the results are twice as great with the 2 as with the 1 per cent.

In view of the fact that this is true, it is now possible to establish the determination on a basis such that comparative and concordant results may be obtained. As 15 cc. $KMnO_4$ consumption, or to the extent of 60 per cent is a good value to handle, it is suggested that samples be chosen which will consume approximately 15 cc. of the 25 cc. of $KMnO_4$ used. By such a procedure it will be possible for two different analysts to obtain comparable values which will be relative to the concentration of the solution.

PROPOSED METHOD

Considering the foregoing, it is suggested that the following procedure be adopted. A sample which will reduce approximately 15 cc. of $KMnO_4$ shall be diluted to 100 cc. with distilled water. To this 10 cc. of $\frac{1}{3}$ H_2SO_4 shall be added and 25 cc. of $KMnO_4$. The whole shall be digested in boiling water for thirty minutes. Twenty-five cubic centimeters of oxalic acid are next added and after solution is complete the whole is titrated to a pink color with $KMnO_4$. A blank determination is carried out in the same manner using 100 cc. of distilled water.

It has been found that oxalic acid is superior to ammonium oxalate or sodium oxalate, in that it retains its strength a longer time. If kept in a brown glass bottle, it will remain unchanged a month. The other two oxalates lose their strength rapidly.

To standardize, the following method is suggested. To 100 cc. of distilled water add 10 cc. of ⅓ H_2SO_4 and bring to boil. Add sufficient $KMnO_4$ solution to bring color equivalent to that obtained by titrating a determination. Next add 25 cc. of the oxalic acid solution and titrate to pink color with $KMnO_4$. This affords a rapid and accurate method of ascertaining the relative strength of the solutions.

THE ELIMINATION OF FALSE PRESUMPTIVE TESTS[1]

By A. C. Janzig[2] and I. A. Montank[2]

The large number of false presumptive tests which are daily encountered in the routine bacterial analysis of a water supply are very troublesome and time-consuming. The lactose-fermenting organisms which are not confirmed as members of the B. coli-aerogenes group prevent the rapid certification of a water supply, since the confirmation test requires 24 to 48 hours longer for completion. A review of the current water works literature clearly indicates the prevalence of these organisms and their annoyance in the B. coli determination.

A large number of investigators have reported on spore-bearing lactose splitting organisms which occur in water supplies. Some of these workers maintain that the anaerobic spore formers are responsible for false presumptive tests. Others believe that the aerobic spore formers are also offenders; while a number of recent observers emphasize the importance of symbiosis, or close association of different species in lactose fermentation.

The gas production in lactose broth by sporulating anaerobes was reported by Frost (1) in 1906; Creel (2) in his examination of drinking water on railroad trains gave reference to the wide spread occurrence of lactose fermenting anaerobes and later they were noted by Hall and Ellefson (3) (4). Levine (5) reported the presence of these organisms in water examined in France; Raab (6) in 1923 found that anaerobes were responsible for 94 per cent of the presumptive tests in Minneapolis water. Meader and Bliss (7) isolated a number of anaerobic strains from lactose broth fermentation tubes showing gas and found that only a few of these attacked lactose.

Spore-forming aerobic bacilli which form gas in lactose broth have been found in water by A. Meyer (8), C. M. Meyer (9), Ewing (10), Sohn (11), and Ruchhoft (12).

The work of Sears and Putnam (13) seems to show that many false presumptive tests develop as the result of symbiotic action brought about by two or more organisms. They found that gas was produced by organisms in

[1] Presented before the Minnesota Section meeting, June 14, 1928.

[2] Bacteriologists and Chemists, Columbia Heights Filtration Plant, Minneapolis, Minn.

various combinations, while none of the organisms concerned would produce gas in lactose broth when growing in pure culture. Since the publication of this work by Sears and Putnam, Sohn (14), Leitch (15), and Dunham, McCrady, and Jordan (16) have become convinced that gas production when produced by anaerobes is the result of a symbiotic relationship.

During the year 1927, at the Columbia Heights Filtration Plant, 1878 tubes of lactose broth produced gas when inoculated with 10 ml. of purified (filtered and chlorinated) water. Out of this large number of gas formers only seven tubes were confirmed as belonging to the B. coli-aerogenes group. Stated in terms of percentage, this means that out of the total number of tubes planted with 10 ml. of treated and chlorinated water, 51 per cent showed the presence of gas, while 99.6 per cent were false presumptive tests. During the first four months of 1928, a still larger number of false presumptive tests were encountered. In this period of 121 days, 1210 tubes of standard lactose were inoculated with 10 ml. each of purified water. Seventy-five and six-tenths per cent of these tubes produced gas, without a single tube showing the presence of the B. coli-aerogenes group.

Water bacteriologists in the past have been alert to this problem and have employed methods of inhibiting false presumptive tests by the addition of several different dyes and bile to the liquid media. In some cases very good results were reported, while in other instances workers reported that the substances employed inhibited organisms of the B. coli group. Most water analysts are of the opinion that the ideal medium to detect pollution is one which will prevent the development of false presumptive tests, and not affect unfavorably the growth of B. coli.

Salter (17) gives a review on the subject of bile salts and says that there is lack of agreement regarding their effect on B. coli and related organisms. Hall and Ellefson (3) and also Muer and Harris (18) have suggested the use of gentian violet and brilliant green to eliminate these disturbing gas formers. Wagner and Monfort (19) say, "How serious may be the inhibition of B. coli by the amount of gentian violet is not yet determined." Their work indicates that the amount of lactose added to the media influences the results obtained. Howard and Thompson (20) at Toronto, Canada, point out that broth made with the addition of bile salt and brilliant green are inhibitory to the colon group. Vale (21), in his annual report, states that lactose broth is to be preferred over the use of lactose bile and safranin because his work has demonstrated that more tubes could

be confirmed by the use of lactose broth. Ruchhoft (12) in his work on Lake Michigan water found a loss of about 50 per cent in confirmations when comparing standard lactose broth with brilliant green lactose bile. He concludes that brilliant green bile broth is too inhibitive to the B. coli group for direct planting into this medium.

The fact that different workers report conflicting results in the use of various concentrations of dyes and bile and combination of dyes in media, emphasizes the complexity of the problem. By the foregoing it would seem that the elimination of false presumptive tests by the addition of dye and bile is in need of more refinement before these inhibitants can be generally adopted in routine practice for the determination of B. coli-aerogenes organisms.

PURPOSE

The principal objective in this work was to develop a method that would eliminate the non-confirming lactose fermenters and yet favor the growth and gas production of the colon group of organisms. A method of attacking the problem other than by the addition of bile and dye inhibitants to the media was desired. A means to this end was suggested by the fact that both B. coli and B. aerogenes will grow well in media adjusted to pH reactions covering a comparatively wide range; while, on the other hand, it seemed plausible that at some point in this range the hydrogen-ion concentration would be such as to inhibit gas production by anaerobes, aerobes, or their combined action. With this in view, experiments were conducted on routine water samples during the latter part of 1927 and continued until the middle of 1928.

EXPERIMENTS AND RESULTS

The lactose broth used in the work was standard dehydrated media prepared by the Digestive Ferments Company. Twenty milliliters of broth were used in each Dunham fermentation tube, which was inoculated with 10 ml. of water to be tested. In the regular routine work this broth had a pH of 6.8 after sterilization in the autoclave at fifteen pounds pressure for twenty minutes. For the experimental work the hydrogen-ion concentration of the broth was adjusted to the desired pH before sterilization. Normal solutions of either sodium hydroxide or hydrochloric acid were used in altering the pH. The colorimetric method as described by Medalia (22) was used in determining the pH of lactose broth. A check of the pH thus ob-

tained was made by using pH colorimetric standards as prepared by La Motte Chemical Company.

In the preliminary experiments, the problem of inhibiting false presumptive tests was carried out by varying the hydrogen-ion concentration of the lactose broth employed. The medium tried out was adjusted to the acid range of pH 5.4 and 6.2, and in the alkaline range varying from pH 7.2 to 8.0. These acid and alkaline tubes of lactose broth were inoculated in parallel with 10 ml. of purified water. The results thus obtained pointed to inhibition on the part of the broth with the lower hydrogen-ion concentration.

TABLE 1

Comparison of standard lactose broth with lactose broth of a higher pH in the elimination of false presumptive tests

DATE	pH	BROTH TUBES		FALSE PRESUMPTIVES	
		Inoculated	Giving gas	Percentage	Percentage eliminated
December 16, 1927 to January 31, 1928	6.8	185	154	83.2	
	8.0	185	87	47.0	43.5
February 1, 1928 to March 14, 1928	6.8	225	200	88.9	
	8.0	225	105	46.7	47.5
April 18, 1928 to May 19, 1928	6.8	190	137	72.1	
	8.0	190	67	35.3	51.1
Total of above	6.8	600	491	81.8	
	8.0	600	259	43.2	47.3

Inasmuch as the preliminary experiments showed that elimination of spurious presumptive tests could be accomplished by decreasing the hydrogen-ion concentration, and because certain writers have demonstrated that members of the B. coli-aerogenes group grow well at this range of pH, it was decided to use lactose broth of pH 8.0 for a basis in the experiments. The purified water used during the work had an average pH of 7.0 and a variation from pH 7.8 to 6.7.

In table 1 the amount of elimination obtained in using pH 8.0 broth is compared with standard lactose broth of pH 6.8. This work covers a period of 122 days in which 600 tubes were used in the

observation. The percentage of elimination in the total number of tubes inoculated amounted to 47.3 per cent.

In table 2 the results are shown when broths of pH 6.8 and pH 8.0 are inoculated in parallel with unchlorinated water containing

TABLE 2

Comparison of standard lactose broth with lactose broth of a higher pH in isolating B. coli-aerogenes organisms from unchlorinated water

DATE	B. COLI DENSITY 0 TO 10 PER 100 ML.	pH OF BROTH	NUMBER OF TUBES	
			Inoculated	Confirmed
February 2, 1928 to April 2, 1928	10 ml. inoculated into each tube	6.8	230	129
		8.0	230	130

TABLE 3

Percentage of gas produced from nine strains of B. coli-aerogenes organisms after 24 hours incubation at 37°C. using lactose broth of various pH values

pH	A	B	C	D	E	F	G	H	I	AVERAGE
5.9	18	17	22	6	17	16	21	16	20	17.0
6.8	11	23	22	19	25	23	16	20	17	19.6
7.5	22	29	27	26	28	27	36	31	20	27.3
8.0	26	23	27	23	29	32	28	31	27	27.3
8.5	26	22	30	27	31	39	30	30	13	27.6
9.0	24	29	32	28	38	37	27	37	17	29.8

TABLE 4

Percentage of gas produced from nine strains of B. coli-aerogenes organisms after 48 hours incubation at 37°C. using lactose broth of various pH values

pH	A	B	C	D	E	F	G	H	I	AVERAGE
5.9	24	32	26	17	25	27	30	21	24	25.1
6.8	18	32	26	32	31	36	25	22	23	27.2
7.5	27	50	31	35	34	36	40	33	25	34.6
8.0	27	40	32	30	35	40	35	34	30	33.7
8.5	28	40	36	33	38	44	41	33	26	35.4
9.0	26	49	42	34	44	36	44	40	31	38.4

members of the B. coli-aerogenes group. All the tubes showing gas were streaked on eosin-methylene blue agar, and typical colonies of B. coli and B. aerogenes were isolated and confirmed. It will be

noted that no inhibition with the pH 8.0 broth resulted in the series of 230 tubes inoculated.

In another phase of the problem, experiments were made in determining what effect the decrease of the hydrogen-ion concentration of lactose broth had on the production of gas, when using pure cultures of B. coli-aerogenes organisms. Nine different strains of these organisms, isolated from raw river water, were inoculated into lactose broth of varying hydrogen-ion concentration adjusted before autoclaving to pH 5.9, 6.8, 7.5, 8.0, 8.5, and 9.0. Gas productions in this series were observed at the end of 24, 48, and 72 hours incubation. The average percentage of gas recorded represents two tubes for each strain. An inspection of tables 3, 4, and 5 indicates that a decrease of the hydrogen-ion concentration in lactose broth produces a larger volume of gas after 24, 48, and 72 hours incubation.

TABLE 5

Percentage of gas produced from nine strains of B. coli-aerogenes organisms after 72 hours incubation at 37°C. using lactose broth of various pH values

pH	A	B	C	D	E	F	G	H	I	AVERAGE
5.9	24	33	28	19	26	27	31	23	24	26.1
6.8	22	32	28	33	32	36	25	22	24	28.2
7.5	28	51	27	35	35	37	41	34	25	34.8
8.0	27	40	33	32	36	40	36	36	30	34.4
8.5	28	41	36	36	39	44	44	34	31	37.0
9.0	26	49	42	36	47	37	45	40	33	39.4

DISCUSSION

The change of reaction in the pH 8.0 lactose broth due to the high temperature of sterilization usually resulted in an increase of hydrogen-ion concentration ranging from 0.2 to 0.4 of a pH unit. Lactose broth adjusted to the neutral range (pH 7.0) changed but very slightly, if at all, upon sterilization. This stability was also true of the lactose broth adjusted to the acid range. These findings are in agreement with the results obtained by Foster and Randall (23). The practice throughout the experiments has been to record the pH of the lactose broth to the value obtained in the adjustment of media before sterilization. When lactose broth is referred to in this work as pH 8.0, the final hydrogen-ion concentration usually ranged between pH 7.6 to 7.8.

The largest number of gas formers eliminated in any one period was obtained during April 18 to May 19, 1928, in which time an elimination of 51 per cent of false presumptive tests was effected. In carrying out the experiments, it was observed that some water samples (of five 10 ml. portions) gave no gas, while in other samples a large number of the tubes showed gas. This would indicate that the concentration of the offending organisms varied in different samples, making the number of these organisms present in water samples an important factor in the problem of elimination.

The proof of the value of any medium advocated in this type of work logically rests upon the quantitative recovery of the B. coli-aerogenes organisms from samples of slightly polluted water. The figures, as shown in table 2, tend to support the use of pH 8.0 lactose broth, since results comparable with those of standard broth were obtained. In 46 samples, comprising 230 tubes tested, the two broths gave equal results. The samples used in the inoculations were unchlorinated filter effluents having a B. coli density varying from 0 to 10 per 100 ml. Thus, each tube of lactose broth received an inoculum which contained between 0 and 1 B. coli organism. Although the number of these experiments is not large, the results should be of special significance, because of the delicacy of the test employed and because the organisms isolated were those ordinarily found in river water and not cultivated laboratory strains.

The B. coli-aerogenes organisms in the progress of growth produce acid, so that a slight concentration of the hydroxyl-ion in the broth would tend to neutralize this acidity, prolonging the desired optimum reactions. Many of the organisms which ferment lactose and give the false presumptive tests are also acid producers; these facts should support the desirability of decreasing the hydrogen-ion concentration of lactose broth in the preliminary inoculations. In a paper just published, Norton and Barnes (24) point out that the presence of Cl. welchii may give a possible interference in routine water examination because of the acidity which these organisms produce when growing in lactose broth. In some cases these writers report that they were unable to isolate B. coli on account of the increasing hydrogen-ion concentration brought about by the growth of Cl. welchii. The percentage of gas produced, as shown in tables 3, 4, and 5 and also in their graphical presentation, apparently confirms the opinion that a prolonged optimum growth of B. coli-aerogenes organisms is secured by decreasing the hydrogen-ion concentration of lactose broth.

Table 3 shows that at the end of 24 hours more gas was produced in the lactose broth of a higher pH than was obtained in using the standard pH 6.8 broth. This fact indicates that the rate of gas production was accelerated over the period of greatest diagnostic value. Levine (25) states that "A small amount of gas in 24 hours is a more reliable index of B. coli than 10 per cent or more gas in 48 hours. The rate of gas production seems more significant than the total volume of gas formed as a presumptive test."

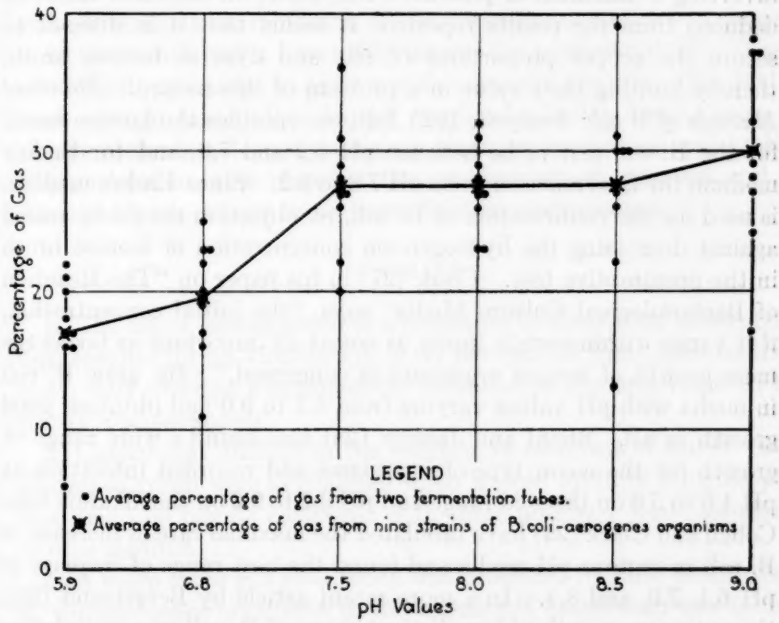

FIG. 1. COMPARISON OF THE PERCENTAGE OF GAS PRODUCED BY NINE DIFFERENT STRAINS OF B. COLI-AEROGENES AFTER TWENTY-FOUR HOURS' INCUBATION, USING LACTOSE BROTH OF VARYING pH VALUES

The relatively greater gas production on the part of the alkaline range remains proportional for all three periods of incubation while the greatest volume of gas was produced in the broth of highest pH reaction. These findings are in keeping with the conclusion drawn by Bronfenbrenner and Schlesinger (26) from their work in lactose fermentation by B. coli. They state, "The amount of gas produced changes inversely with variations in the hydrogen-ion concentration, other conditions being equal."

The idea of using the hydrogen-ion method in the control of false presumptive tests is a feature which not only is new and apparently effective, but may lend itself to wide application in the bacteriological control of water supplies. The procedure is a departure from what has been used in the past for the elimination of spore-forming lactose fermenters, since no inhibitants as dyes or bile are added to the lactose broth, but only a decrease of hydrogen-ion concentration is employed. The application of this means is simple and practicable, involving a minimum of possible error; while, on the other hand, as deduced from the results reported, it seems that it is difficult to secure the proper proportions of bile and dyes in lactose broth, thereby limiting their value in a problem of this nature. *Standard Methods of Water Analysis*, 1925 Edition, specifies the lactose broth for the B. coli test to be between pH 6.2 and 7.0, and for Endo's medium the final reaction to be pH 7.8 to 8.2. Since Endo's medium is used for the confirmation of B. coli, no objection should be raised against decreasing the hydrogen-ion concentration of lactose broth in the presumptive test. Clark (27) in his paper on "The Reaction of Bacteriological Culture Media" says, "the initial concentration, if it varies within certain limits, is not at all important as far as the mere growth of certain organisms is concerned." He grew B. coli in media with pH values varying from 5.5 to 9.0 and obtained good growth in all. Shohl and Janney (28) also found a wide range of growth for the colon type of organisms and recorded inhibition at pH 4.6 to 5.0 on the acid range and pH 9.2 to 9.6 on the alkaline side. Cohen and Clark (29) have tabulated the maximal rate of increase of B. coli in various pH media and found the best range of increase at pH 6.1, 7.0, and 8.1. In a more recent article by Bergstrand (30), the optimum growth of two distinct types of B. coli was recorded as follows: D type optimum pH 6.3 to 8.2, S type optimum pH 5.2 to 8.2.

In using a lactose broth of a higher pH it has been demonstrated that the false presumptive tests are partially eliminated while the growth of the B. coli-aerogenes organisms apparently was stimulated. The problem of eliminating these false tests with pH control of broth will require more extensive research in the bacterial analysis of waters from various localities. It is a well known fact in water purification that not all waters will respond to the same treatment. It may also be true in work of this character since the pH of waters varies considerably. Buswell (31) gives a table of the pH values of

filtered water from 20 different towns, and it is noted that they range from pH 6.0 to 8.1. This difference in waters would suggest that a different pH of lactose broth used in the B. coli determination would be more effective for each individual water supply.

In viewing the results obtained, the question naturally arises, what is the character of the inhibitive mechanism involved? Is the inhibition of false presumptive tests due to the decrease in the hydrogen-ion concentration of the lactose broth? Is there a change in the composition of a medium of a relatively high pH brought about by autoclaving? Is the inhibition due to a combination of both a change in lactose broth and a lowered hydrogen-ion concentration? These are difficult questions to answer with adequate theories. No doubt some change takes place in the sterilized alkaline broth, since it always presents a deeper color than the more acid or neutral broth. Experiments on this phase of the problem are in progress and a subsequent paper may throw some light on the question.

SUMMARY

1. The use of lactose broth of a decreased hydrogen-ion concentration resulted in an elimination of 47 per cent of false presumptive tests, thus effecting a considerable reduction in the time required to certify a water supply.

2. Concordant findings in the isolation of members of the B. coli-aerogenes group were established when lactose broth of a higher pH was used and results compared with those obtained from standard routine medium.

3. A more rapid gas production was produced by pure cultures of B. coli-aerogenes organisms in the higher pH broth than was found with lactose broth as recommended by *Standard Methods*.

4. No equipment was used other than that ordinarily employed in the standard procedure.

5. A reduction in the cost of bacterial analyses was made possible since less media was required.

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REPORT OF THE FINANCE COMMITTEE, 1926 AND 1927

Your Committee presents the following report of the finances of the American Water Works Association for the year ending December 31, 1926.

At the 1926 Convention held at Buffalo, the Association authorized the employment of a full time Secretary and directed that he should attend at least once a year a meeting of each of the sections. As our Association has local sections in all parts of the United States and in Canada this greatly increased the expense of the Secretary's Office.

The budget and direct operating expenses for 1926 were as follows:

Item	*Budget Allowance*	*Actual Expense*
1. Convention Expense	$1,400.00	$1,728.17
2. Office Expense	2,000.00	1,698.63
3. Committee Expense	3,000.00	2,240.09
4. Section and Division Expense	1,600.00	1,848.81
5. Insurance	100.00	47.00
6. Office of Secretary	13,250.00	9,685.89
7. Salary of Editor	2,000.00	2,000.00
8. Printing of JOURNAL	16,500.00	20,815.65
9. Contingencies	200.00	88.76
10. Rent of Offices	1,200.00	1,300.00
Exchange on checks		13.65
Depreciation—Office Furniture		86.32
	$41,250.00	$41,362.92

Besides the above there were other expenses as follows:	
Cost of Manual Compilation—Final Payment	$1,271.87
Purchase of Manuals	866.25
Hydrant, Valve and Pipe Specifications	17.87
Reprints	199.60
Binders	22.42
Diven Memorial Medical—Cost of Die	762.10
	$3,140.11
Total Expenditures	$44,503.03

Of the above the final payment on the cost of Manual compilation and the Diven Memorial die were extraordinary expenses and will

not occur again. Purchase of manuals, specifications, reprints and binders are items for which the Association is reimbursed.

The Auditor's report of the finances of the Association shows that the total cash receipts for 1926 were $36,883.15, an increase of $5,181.72 over the previous year; the total expenditures were $40,963.60, an increase of $7,525.29 over 1925. The excess of expenditures practically exhausted our working cash balance, but it must be remembered that the increased dues were not available in 1926.

No change has been made in the amount of our invested capital which amounts to $11,945, and your committee feels that this sum should be retained intact.

Conservatively estimated the receipts for 1927 should be as follows:

Initiation Fees	$1,500.00
Annual Dues	27,000.00
Advertising	18,000.00
Interest on Investments and Current Fund	800.00
Subscriptions and Sales of JOURNAL	1,600.00
Royalties and Sales of Manuals	300.00
Small Miscellaneous Items	100.00
	$49,500.00

At the January, 1927 meeting of the Executive Committee in New York the following 1927 budget was adopted:

Itemized Budget Allowance

	Amount
1. Convention Expense	$1,700.00
2. Office Expense	2,000.00
3. Committee Expense	3,700.00
4. Section and Division Expense	3,000.00
5. Insurance	100.00
6. Office of Secretary	14,000.00
7. (a) Salary of Editor	2,000.00
(b) Proof Reading, etc.	1,000.00
8. Printing of JOURNAL	18,000.00
9. Contingencies	200.00
10. Rent of Office and Additional Office Equipment	2,500.00
	$48,200.00

It was further recommended that additional income above the budget of $48,200.00 should be applied toward building up a cash surplus.

Your Committee has examined and approved all vouchers presented during the year.

As customary the books of the Association have been examined and audited by Chirnside, Roberts & Langston, accountants and auditors, and their report has been submitted to the officers of the Association, and is on file in our office.

Your Treasurer is bonded for $10,000.00 and your Secretary for $2,000.00.

Your Committee feels that the Association is now on a sound financial basis, but wishes to emphasize the necessity of building up the working capital in the next few years and consider that any expenditures in excess of the present budget would be most unwise.

In conclusion, your Committee wishes to extend its thanks to Secretary Little, Treasurer Brush, and Assistant to the Secretary, Mr. Niesley for their coöperation.

Respectfully submitted,

CHAS. R. BETTES,
E. G. WILHELM,
GEORGE C. ANDREWS, *Chairman.*

REPORT OF THE FINANCE COMMITTEE, 1928

Mr. George C. Andrews, Chairman of the Finance Committee, resigned just previous to the 1928 Convention because of pressure of other duties and no formal report of the Finance Committee was made. However, at the January, 1928 meeting of the Executive Committee, the Finance Committee presented a tentative budget for the year 1928 and this was adopted, and with some minor changes, approved by the Executive Committee and the Association at the San Francisco Convention in June, 1928. This final 1928 budge is as follows:

Item	*Amount*
1. Convention Expense	$2,050.00
2. Office Expense	2,350.00
3. Committee Expense	4,850.00
4. Section and Division Expense	3,500.00
5. Insurance	100.00
6. Office of Secretary	14,000.00
7. Salary of Editor and Editor's Assistants	3,000.00
8. Printing of JOURNAL	20,000.00
9. Contingencies	200.00
10. Rent of Office	1,450.00
	$51,500.00

The auditor's report of the Association finances for the year 1927 shows the following figures;

Total Income for 1927	$51,070.75
Total Expenditures for 1927	46,604.71
Income over Expenditure	$4,466.04

The permanent fund of the Association, by authorization of the Executive Committee in 1928, was increased by $2,000.00 taken from the excess receipts of 1927. It now totals $14,000.00.

The estimated receipts for 1928 indicate that the Association will be well able to take care of this year's increased budget.

Respectfully submitted,

BEEKMAN C. LITTLE,
Secretary.

SOCIETY AFFAIRS

THE ANNUAL CONVENTION

About 600 persons attended the forty-eighth annual meeting of the American Water Works Association at the Fairmont Hotel, San Francisco, California.

Monday, June 11. Sessions of the Plant Management and Operation Division and of the Committee on Standard Methods of Water Analysis, on the afternoon of Monday, June 11, preceded the formal opening of the convention. The meeting of the Plant Management and Operation Division took the form of a Superintendent's Round Table discussion under the chairmanship of W. E. MacDonald.

William W. Brush opened the discussion on the subject of "A New Band for Large Cast Iron Pipe." This was followed by a discussion of installation practice for hydrants and valves by J. L. Prugh, S. B. Morris[1] spoke on the subject of "Dead Ends," V. E. Perry on "Leak Surveys" and J. S. Peters on "Standpipes, Tanks and Reservoirs."

The meeting of Committee No. 1 on Standard Methods of Water Analysis was held under the chairmanship of Jack J. Hinman, Jr.

On Monday evening a reception and dance were held in the Terrace Ball Room of the Fairmont Hotel.

Tuesday, June 12, Morning. The convention was formally opened by the president, James E. Gibson, at nine o'clock, Tuesday morning, June 12. Mr. Gibson called attention to the fact that in opening the forty-eighth annual convention at San Francisco he was using the gavel used by F. A. W. Davis, as president at the 17th Annual Convention in Denver, Colorado, in June, 1897. Two conventions, the sixth in 1886, and the seventeenth in 1897, were held in Denver, but no more western city was selected until the forty-eight convention was scheduled to be held in San Francisco.

Beekman C. Little, secretary, announced the result of the election of officers for the year 1928–1929, as follows:

President, W. W. Brush; Vice-president, Jack J. Hinman, Jr.;

[1] This Journal, page 608.

Treasurer, George C. Gensheimer; Trustees, District No. 1, C. D. Brown; District No. 2, Stephen H. Taylor; District No. 6, John Chambers.

Mr. Little read the reports of the secretary and the treasurer. A gain of 121 members during the year was recorded. A budget of $51,500 was recommended by the Budget Committee and was approved.

It was announced that the award of the John M. Diven Memorial Medal given annually to the individual who does most for the association during the year just completed had been made to W. S. Cramer, superintendent of the Lexington Water Co., Lexington, Kentucky.

The work of the Committee on Electrolysis was discussed. The attempts of the president and others with regard to income tax adjustments for water works superintendents and employees were described.

Two papers were read at this session: "The Coefficients of Electrolytic Corrosion of Brass and Copper Pipes," by K. H. Logan,[2] and "Seasonal Growths of Plankton in Reservoirs and Measures for their Control," by C. A. Kofoid.

The conference of Committee No. 19, Boiler Feed Water Studies, Sheppard T. Powell, chairman, was opened by Jack J. Hinman, Jr., in the absence of Mr. Powell. The paper by Frank G. Philo,[3] entitled "Control of Condenser Tube Corrosives by Electrolytic Corrosion Method," was read by Mr. Jensen of the Southern California Edison Co., Los Angeles, of which company Mr. Philo is the superintendent of steam generator stations.

In the absence of R. E. Hall, his paper was read by Jack J. Hinman, Jr., acting chairman, on "Prevention of Scale Formation and Relation to Smooth Boiling and Wet Steam."

Mr. Hinman read the paper by Chairman Sheppard T. Powell of the Boiler Feed Water Studies Committee. This paper was entitled "Activities of the Boiler Feed Water Studies Committee" during the past year, and listed 27 items on which it is hoped to begin active investigations. The financial arrangements as well as the present needs of the committee were detailed. A budget of $60,000 per year for a period of five years is the goal set in order that the work may be properly financed.

[2] Journal, September, 1928, page 390.
[3] Journal, October, 1928, page 505.

Tuesday, June 12, Afternoon. The paper entitled "Selection of Pumps to Fit Service Conditions," by F. G. Cunningham,[4] was read by title.

George D. Conlee presented a paper on the "Pitot Tube in Water Works Practice."

L. R. Howson[5] read his paper entitled "Unaccounted for Water." This paper was extensively discussed.

Mr. Howson was followed by Edward Hyatt, who read a paper describing "A State Water Policy for California."

Helman Rosenthal, discussed the "Protection of Impounded Watersheds." There was considerable difference of opinion expressed from the floor on this subject.

Boiler Feed Water Studies

The conference of Committee No. 19 on Boiler Feed Water Studies was continued during the afternoon of Tuesday, June 12, under the acting chairmanship of Jack J. Hinman, Jr. In the absence of Frederick G. Straub, his paper on "Water Treatment to Prevent Embrittlement," was read by the acting chairman.

L. O. Gunderson read a paper on the subject of "Electrolytic Methods for the Prevention of Corrosion in Steam Boilers—Theory and Practice."

During the afternoon an exhibit of difficult connections and a demonstration of pipe joints was conducted in the vicinity of the hotel by L. I. Farrell, superintendent of the East Bay Water Company of Oakland, California.

Immediately after the conclusion of the afternoon program the representatives of the nine geographical sections met to choose the members of the nominating committee. The result of the selection of committee personnel was as follows: District No. 1, A. U. Sanderson; District No. 2, Patrick Gear; District No. 3, John M. Diven, Jr.; District No. 4, Charles L. Fox; District No. 5, A. P. Michaels; District No. 6, C. A. Brown; District No. 7, W. T. Mayo; District No. 8, W. W. DeBerard; District No. 9, S. B. Morris.

General Sessions.

Tuesday, June 12, Evening. The evening session consisted of two papers descriptive of the two leading local water supplies, those

[4] Journal, August, 1928, page 171.

[5] Journal, September, 1928, page 349.

of the Spring Valley Water Company and the Hetch-Hetchy Water Supply. G. A. Elliott[6] gave a general description of the water supply of his company. M. M. O'Shaughnessy explained the features of the Hetch-Hetchy supply and told the history of the project.

While the evening session was in progress the ladies were entertained with a card party.

Wednesday, June 13, Morning. The general session was opened with the paper by E. A. Rowe, on "Experience in Construction of a Large Size Gunited Steel and Centrifugally Cast Concrete Pipe Line."

The paper on "Pitometer Surveys," by Cyrus R. Bird, followed.

In the absence of the author, William Mulholland,[7] the paper on the "Colorado River Water Supply" for the Los Angeles Metropolitan District, was read by W. W. Hurlbut.

Howell Wright read a paper on "Diversion of Funds from Water Departments for Other Municipal Purposes."

"Substitution of Ground Water Supply for Filtered Water," was read by E. T. Archer.

The paper by H. S. Greene,[8] "Cost of Machine Trenching and Backfilling," was read by J. M. Bruns.

Water Purification Division

The Water Purification Division met under the chairmanship of Wellington Donaldson. Edward A. Reinke acted as secretary of the section in the absence of Harry E. Jordan. The paper on the "Chemical Reactions of Sodium Aluminate" by A. M. Buswell, was read in abstract, as the author was not present.

H. N. Jenks read "Notes on Engineering Studies of Municipal Zeolite Water Softening."

Lyle L. Jenne, sent his paper "How Standard are Standard Methods?" to the meeting, where it was read by Jack J. Hinman, Jr., who also discussed the paper.

"Experiences with Crenothrix in Ground Water Supplies" was the subject of a paper by Kenneth W. Brown.

A. J. Salle read a paper entitled "The Differentiation of the Coli and Aerogenes Groups of Bacteria."

[6] Journal, September, 1928, page 294.
[7] Journal, October, 1928, page 463.
[8] Journal, October, 1928, page 496.

F. R. McCrumb submitted a paper on "A New Method of Determining Dissolved Oxygen."

Report of Nominating Committee

The nominating committee elected at the Tuesday afternoon session held a meeting at 9.45 a.m., Wednesday, and brought in the following slate for officers:

For president: Jack J. Hinman, Jr.; for vice-president, George H. Fenkell; for treasurer, George C. Gensheimer; for trustees, District No. 3, J. Walter Ackerman; District No. 5, A. F. Porzelius; District No. 7, W. T. Mayo.

Excursions

For Wednesday afternoon two excursions were provided through the courtesy of the California Section of the American Water Works Association.

Trip No. 1 was a visit to San Francisco's Sky Line Boulevard, the properties of the Spring Valley Water Company and Stanford University at Palo Alto, where an organ recital was given in the University Chapel. The party returned via the State Highway through Redwood City, San Mateo and Burlingame.

Trip No. 2 visited the East Bay cities including Oakland, Piedmont, and the University of California at Berkeley and the San Pablo and Upper San Leandro water filtration plants of the East Bay Water Company.

On the return from these excursions separate entertainment for the ladies and the gentlemen was arranged. The ladies attended a theatre party at the Geary Theatre. The men were guests at a smoker in the Terrace Room of the Fairmont Hotel. A splendid program was provided, chiefly by radio entertainers from Radio Station KFRC. These entertainments were provided by the Water Works Manufacturers' Association.

Water Purification Division

The Water Purification Division held its annual dinner at 6.45 p.m. in the Gray Room at the Fairmont Hotel. Chairman Wellington Donaldson presided. No formal program followed the dinner.

The meeting of the Water Purification Division was told that there was an interesting grouping of the members of the division as regards

occupations. Cards were sent to all members during the current year and the replies of 1,195 individuals were tabulated. Because many of the men did work in more than one classification, the total classifications were distributed as follows: Superintendents, 467; engineers and private practice, 304; operators, 185; chemists and bacteriologists, 145; government supervision, 132; municipal and state, 132; teachers, 51; miscellaneous, 99.

Plant Management and Operation Division

Thursday, June 14, Morning. The Plant Management and Operation Division met under the chairmanship of W. E. MacDonald.

The first paper was that of R. B. F. Chisholm, on the subject of "Uniform Water Works Accounting."

In the absence of the author, the paper on the "Management of Water Works Business from the Executive Office Standpoint," by George H. Fenkell,[9] was read by D. C. Grobbel. Discussions by Theodore A. Leisen, H. S. Morse and C. S. Denman, were read.

W. W. Hurlbut[10] discussed the subject of cast iron service pipe.

A paper by R. B. Morse[11] on "Copper Service Pipe" was read.

President James E. Gibson told of the construction of a 60-inch tunnel built at the Water Works of Charleston, South Carolina, where he is manager and engineer.

Water Purification Division

Wellington Donaldson, the chairman of the division, presided. R. L. Derby discussed "Hydrogen Sulphide Removal and Water Softening at Beverley Hills."

"The Operating Experiences with the East Bay Filtration Plants" were related by W. F. Langelier and Joseph DeCosta.

R. A. Stevenson reported upon "Operating Experiences with the Sacramento Filters."

The paper, "Experiences with Covered and Uncovered Reservoirs at Washington, D. C." by Carl J. Lauter, was read in abstract by Abel Wolman.

Fermentation tubes of modified Smith type, as used at the plant of the city of Philadelphia, were shown and described by George G. Schaut.

[9] Journal, September, 1928, page 308.
[10] This Journal, page 595.
[11] Journal, August, 1928, page 163.

General Session

Thursday, June 14, Afternoon. At the general session the first paper was that of J. T. Campbell and D. E. Davis on "Softening of Municipal Water Supplies by Use of Zeolites."

The paper entitled "Reforestation of Water Sheds," by Edgar P. Kable,[12] was delivered by Abel Wolman.

The paper by D. C. Henny,[13] on the "Failure of the St. Francis Dam of the Los Angeles Water Supply," was read. The paper on the same subject which was to have been given by A. J. Wiley,[14] was not presented.

Leonard A. Day read an illustrated paper on "A Description of the New Missouri River Water Works of the St. Louis Water Division, Howard Bend, St. Louis County, Missouri."

"Coefficients of Flow in Concrete Pipe" was the subject of the illustrated paper by Fred. C. Scobey.

The paper entitled "Development of Water Works in the South," by W. T. Mayo, was a general one.

Water Purification Division

The concluding session of the Water Purification Division was held on Thursday afternoon. The first paper was that of N. T. Veatch, Jr., on "Protection of an impounded Supply from Pollution by Oil Field Wastes and Highly Mineralized Irrigation Water."

The experiences of the Water Department of Kansas City, Kansas, with an open distribution reservoir formed the basis of the paper, "Algae Control by Chlorination," by L. B. Mangun.

Dana E. Kepner[15] discussed the subject of "Chloro-Phenol Tastes from Creosoted Wood-Stave Pipe in Colorado."

A report on the "Progress in Water Chlorination during 1927–1928" was read by Linn H. Enslow.

Since the time was becoming short and there had already been held an open meeting on the Committees' work, the scheduled report of Committee No. 1 of the Standardization Council, Jack J. Hinman, Jr., chairman, was not given in a formal manner. Chairman Donaldson merely explained the developments.

[12] This Journal, page 635.
[13] Journal, September, 1928, page 343.
[14] Journal, September, 1928, page 338.
[15] Journal, October, 1928, page 473.

The Committee of the Water Purification Division on Revision of the Manual, Paul Hansen, chairman, made its report and requested that it be discharged. The recommendation was accepted.

The Committee of the Division on Purification Data and Forms, of which James W. Armstrong is chairman, brought in a progress report stating that a questionnaire is being sent around to secure the information which is to be collected for a report to be presented later. Insufficient time has prevented the collection of the data and therefore a continuance of the committee was asked and granted.

The Nominating Committee of the Water Purification Division, consisting of Almon L. Fales, A. U. Sanderson and Jack J. Hinman, Jr., brought in a ticket as follows: For chairman, Wilfred F. Langelier; vice chairman, Charles P. Hoover; secretary-treasurer, Harry E. Jordan; director, A. C. Decker. The officers were elected by the Division as indicated in the nomination list.

At 7.30 p.m., the Water Works Manufacturers' Association entertained about 700 persons with an excellent banquet. There was no program of speeches following the banquet, but as soon as the dinner was over the guests went to the Terrace Room where a dance orchestra provided music.

General Session

Friday, June 15, Morning. The papers included the following: "Interstate River Compacts and Their Place in Water Utilization," by Delph E. Carpenter and R. I. Meeker; "Campaigns to Increase Water Sales," by Lewis W. Britton; "Failure of a 48-inch Cast Iron Main Under Earth Pressure," by Wm. W. Brush; "Control of Stresses in Pipe Line Construction," by L. T. Jones and Walter S. Weeks;[16] "Financing of Extensions in Territory Only Partially Remunerative at Time of Construction," by Charles L. Fox.

The following committee reports were also considered: "Industrial Wastes in Relation to Water Supply," Almon L. Fales, Chairman; "Standardization of Pipe Fittings and Flanges," F. A. Barbour,[17] Chairman; "Simplification and Standardization of Manhole Frames and Covers," Frank A. Marston,[18] Chairman; "Standard Form of Contract," J. Waldo Smith,[19] Chairman.

[16] Journal, October, 1928, page 449.
[17] Journal, May, 1928, page 610.
[18] Journal, October, 1928, page 567.
[19] Journal, October, 1928, page 563.

At a joint session of the Plant Management and Operation Division and the Superintendents' Round Table Discussion the replies considered were a questionnaire sent out to a large number of cities. The replies were sent in to W. E. MacDonald and tabulated by him for discussion at the round table meetings. A summary of the replies to the various questions has been published in the JOURNAL.[20]

CANADIAN SECTION

The eighth annual meeting of the Canadian Section was held from Wednesday, March 7, to Friday, March 9, 1928, in London, Ontario, with headquarters at the London Life Insurance Building.

The convention was the most successful in the history of the Canadian Section and the attendance was the largest on record and amounted to:

Active and corporate members	82
Guests actively interested in the management of water works, chairmen and members of water commissions, etc.	82
Associate members and exhibitors	83
Ladies	27
Total	274

The convention opened on Wednesday morning with registration and inspection of the excellent exhibit of the Water Works Equipment Association.

An informal luncheon was held in the Hotel London and, after a few words of welcome from the Chairman, D. McL. Hanna, a paper was presented on "The London Water Works" by E. V. Buchanan, Manager of the London Public Utilities Commission. At the close of this paper the delegates were taken on a tour of inspection over the London Water Works which included the reservoir and pumping station at Springbank and the wells and pumping station and shops in the city. While the members were making this tour, the ladies were taken for an automobile drive through the city and were entertained at tea at the Sanitarium at Springbank.

At the evening session, a paper was read on "The Value of Laboratory Tests in Water Works Operation" by A. E. Berry, after which the manufacturers' exhibits were inspected and the members were entertained at a manufacturers' hour. The ladies attended a theatre party in the evening.

[20] Journal, September, 1928, page 381.

The business meeting opened on Thursday morning and the Secretary-Treasurer presented his financial report, which was audited by Messrs. Miller and Gore. The Chairman appointed Messrs. Charles Warder, Niagara Falls, Alexander Milne, St. Catherines and C. D. Brown, Walkerville to the Nominating Committee for 1928–1929 and Messrs. Alexander Milne and C. D. Brown to the Resolutions Committee.

A number of changes in the constitution were made, viz.: The trustees to be elected each year to serve for a three-year period were changed from one to two; the representative for District No. 1, Canadian Section, on the Executive Committee of the parent body, was made ex-officio a member of the Executive of the Canadian Section and the time for holding the annual convention was augmented by adding August or September to the months February and March.

The chairman then asked Mr. B. C. Little, the Secretary of the A. W. W. A., to address the meeting and Mr. Little spoke about the coming convention in San Francisco and the fall meeting of the N. E. W. W. A. in September, which might be held in Montreal.

The place for the next annual meeting was not decided, because there was a possibility that the general convention of the A. W. W. A. would be held in Toronto in 1929, in which case the Canadian Section would hold a joint meeting with the parent body.

The scrutineers, Messrs. Clark Keith and N. R. Wilson, reported that the following officers had been elected for the Canadian Section for 1928–1929.

Chairman, J. O. Meadows, Montreal.

Vice-Chairman, W. C. Miller, St. Thomas.

Trustee, E. V. Buchanan, London.

The Secretary of the Canadian Engineering Standards Association, B. Stuart McKenzie, addressed the delegates regarding the standardization of hose connections for Canada and, after some discussion, the matter was left to the Executive Committee with full power to act.

In the afternoon papers were read on "Electrolysis and Its Mitigation" by W. B. Buchanan, and "Water Main Cleaning" by Wm. H. Grotz.

In the evening, the annual dinner was held in the Hotel London and after addresses by the chairman, D. McL. Hanna, His Worship, Mayor Wenige, and Commissioner Jared Vining, an excellent vaude-

ville program was provided through the courtesy of the Water Works Exhibitors Association and this was enjoyed by everyone. After the dinner, the ladies attended a bridge party in the Hotel London.

On Friday morning, the general sessions were resumed and R. E. Thompson gave a paper on "Water Softening;" Alexander Milne gave an account of "One Year's Operation of the St. Catherines Filtration Plant" and G. G. Routledge a paper on "Methods of Carrying Water Mains on Bridges and Viaducts."

In the afternoon the questionnaire on practical water works matters was held and much valuable information and experiences were exchanged by the members.

The secretary-treasurer, A. U. Sanderson, was re-elected by the Executive and J. J. Salmond was re-elected as a representative of the Water Works Equipment Association on the Executive Committee of the Canadian Section.

The convention closed at 5:00 p.m., after short addresses by E. V. Buchanan, the newly elected Trustee and D. McL. Hanna, the retiring Chairman.

A. U. SANDERSON,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN[1]

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Problems Encountered in Building Cement Receiving Reservoir. T. R. HASELTINE. Southwest Water Works Journal, **10**: 3, 9–11, June, 1928. A reservoir 111 feet square inside by 15 feet deep was built in sand and gravel with normal ground water level about 12 feet above bottom. Methods of dewatering and of laying concrete are described. Water ratio and slump test were used to control concrete mix. Celite was used for waterproofing.—*J. H. O'Neill.*

The Oil Field Salt Water Pollution Problem. J. G. MCINTOSH. Southwest Water Works Journal, **10**: 3, 12–13, June, 1928. A discussion of the problem with particular reference to conditions in Texas. An attempt at control by evaporation upon a tremendous scale failed when raining spell washed mountains of salt into streams with resulting lawsuits. In Mexia district large impounding reservoirs to be discharged during flood periods served for two years but accidental discharge during a dry spell brought lawsuits and abandonment of project. Present method in this district is to buy up riparian rights on certain streams used as drains. A suggestion that the salt water be pumped back into ground through "dry holes" is discussed.—*J. H. O'Neill.*

The Differentiation of Fecal from Non-Fecal Colon Bacteria. I. M. LEWIS. Southwest Water Works Journal, **10**: 3, 15–16, June, 1928. A brief discussion of the sanitary importance of determining whether members of this group are of fecal or non-fecal origin and of methods and culture media for differentiation.—*J. H. O'Neill.*

Sewage Treatment in the Region of Chicago. PAUL HANSEN. Southwest Water Works Journal, **10**: 3, 25–30, June, 1928. A brief description is given, with some design data, of the numerous plants which have been built or are planned by the various sanitary and conservancy districts of the region near Chicago which is rapidly becoming the center of the greatest development in the sewage treatment field in the world.—*J. H. O'Neill.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Design Data for Rapid Sand Filters. A. L. LIVINGSTON. Southwest Water Works Journal, **10**: 3, 31–33, June, 1928. Attention is called to a few general features of design of a rapid sand filter plant "so that the waterworks superintendent, city official, or filter operator may know some of the problems that the consulting engineer has had to consider in designing the plant."—*J. H. O'Neill.*

Saving Money by Use of Elevated Tanks. GEORGE H. FENKELL, Water Works Engineering, **81**: 9, April 25, 1928. The elevated storage of water in a proper location has the following advantages: (1) Reduction of operating costs at the pumping station, (2) Maintenance of more uniform pressures throughout the year, (3) Reduction of capital costs for pumps and mains to meet the peak hour demand, (4) Improved fire service, (5) Maintenance of pressures during a short interruption of pumping service, (6) Less pump manipulation required. Cost of elevated tank, exclusive of cost of site, and with an elevation at the top of 100 feet runs from $10,000 for a 100,000-gallon tank to $90,000 for a 1.5-m.g. tank. Only one tank, capacity 2 m.g., has been constructed so far, while four 1.5-m.g. tanks are nearing completion in Detroit. Tank should be located on that side of the center of the district in which much of the water is consumed, opposite from the pumping station, near a main line which is large enough to allow tank to operate satisfactorily and upon land that is as high as, or higher than, most of the district that will be affected. As all of these requirements will not be met with in any particular case, a practical solution must be found that best meets existing conditions. Thorough study of soil necessary in order to insure safety of structure. Uneven settlement may develop excessive stresses in certain members. Experience with tanks as large as, or larger than, 1-m.g. during winter season in northern latitudes is limited, because so few have been constructed. Unless a tank is heated or protected, it should not be so operated that there will be but little flow in and out during severe freezing weather, for should water remain at about the same level for a week or more, with air temperatures at zero or below, ice would form with consequent trouble. In determining size of tank not only balancing effect on system should be considered, but also storage of water for fire protection purposes.—*Carl Speer, Jr.*

Water Purity Increased by Progress of Chlorination. W. J. ORCHARD. Water Works Engineering, **81**: 7, 409, March 28, 1928. It is estimated that of surface waters used as public supplies in North America well over 90 per cent by volume is being chlorinated. Chlorination of underground waters is continually on the increase. Chlorination is recommended as best method of sterilizing water in swimming pools. Chlorination of sewage and industrial wastes is also increasing. The biological oxygen demand of sewage is decreased by chlorination. Odors at sewage plants can be controlled by chlorination. The whole cause of chlorination is being injured because in a relatively small minority of installations chlorination is being asked to carry a load that it is incapable of carrying alone. Chlorination will not filter a water; it will not appreciably remove color or turbidity. Chlorination, regardless of its sterilizing quality, cannot be made to take the place of water purification

works. Chlorination to be uniformly successful must be controlled by *ortho*-tolidin tests and all chlorination installations should be in duplicate, so that interruption of service will be avoided.—*Carl Speer Jr.*

Make Your Plant Records Complete. HELMAN ROSENTHAL. Water Works Engineering, **81**: 11, 673, May 23, 1928. In a water plant it is vitally important to keep accurate records of chemicals used, tests made, and results obtained. These are necessary to inform consumers of needs and improvements. Records should include: (1) Amount of raw water received and treated, (2) Chemical and physical condition of raw water and its bacterial and *B. coli* content, (3) Amount of chemicals added per gallon and effects, (4) Data on settled water, (5) Condition of water on filters, (6) Length of operation of the filters between washings, amount of wash water. It is most important that the records be easily interpreted.—*Carl Speer, Jr.*

Method of Testing of Mineral Water for Pollution with Illuminating Gas. REGENSTEIN. Chem.-Ztg., **51**: 737-8, 1927. From Chem. Abst., **22**: 287, January 20, 1928. By ether extraction, 1.3 p.p.m. phenol can be detected with bromine water or 0.1 p.p.m. with Millon's reagent. About 0.1 p.p.m. of sulfocyanide can be detected. Water saturated with gas gives no test for phenol, sulfocyanide, or cyanide. Oxygen consumed on boiling for 10 minutes or standing 24 hours at 45° is above normal. About 6 p.p.m. chlorine is absorbed in 24 hours in dark as compared with 0.4 p.p.m. for water uncontaminated. Iodine absorption is small. By distillation, carbon monoxide can be detected with palladium chloride. Defibrinated blood is less sensitive. By distillation, Cu $(NH)_2$ will detect acetylene in concentration where palladium chloride gives no reaction for carbon monoxide.—*R. E. Thompson.*

Influence of Cemeteries on Potable Water Sources. J. HUG. Monats-Bull. schweiz. Ver. Gas- u. Wasserfach., **7**: 273-7, 1927. From Chem. Abst., **22**: 288, January 20, 1928. Literature in regard to influence of cemeteries on bacteriological and chemical composition of ground water indicates little if any deleterious influence. Experimental work confirms this and HUG concludes that "cemeteries can affect the quality of ground water in the neighborhood only to a very slight extent."—*R. E. Thompson.*

The Solution of Oxygen in Sewage. A. S. PARSONS and H. WILSON. Surveyor, **72**: 490, 1927. From Chem. Abst., **22**: 289, January 20, 1928. Apparent absorption of oxygen is due to action of bacteria. Curves given showing oxygen found during passage of air bubbles through sewage and water, and through sewage of adjusted pH values. Change in pH greatly alters shape of curve.—*R. E. Thompson.*

Investigations of Polluted Waters. DAVID ELLIS. Surveyor, **70**: 162, 1926. From Chem. Abst., **22**: 289, January 20, 1928. Beggiatoa alba is good indicator organism.—*R. E. Thompson.*

Casting Pipes of Metal, Hydraulic Cement, or other Materials, in Vertical Centrifugal Molds. C. BILLAND. Brit. 265,587, February 2, 1926. From Chem. Abst., **22**: 287, January 20, 1928.—*R. E. Thompson.*

River Pollution. F. A. B. PRESTON. J. Roy. Sanit. Inst., **46**: 350, 1926. From Chem. Abst., **22**: 288, January 20, 1928. Precise definition as to what constitutes pollution is needed.—*R. E. Thompson.*

Practicability of the Benzidine Method for Sulfuric Acid Determination in Water Analysis. L. W. HAASE. Chem.-Ztg., **51**: 760, 1927; cf. C. A. **21**: 3997. From Chem. Abst., **22**: 288, January 20, 1928. HAASE replies to inquiries, admitting that his method is not as ideal as critics would wish it to be. —*R. E. Thompson.*

Experiments on the Purification of Chemical Trade Effluents and Sewage Containing Chemical Trade Effluents with Activated Sludge. W. D. SCOULLER. Surveyor, **70**: 535, 1926. From Chem. Abst., **22**: 288, January 20, 1928. Chemical effluents treated with excess lime, settled, and excess lime neutralized have been purified by activated sludge process. Acids and salts of iron and aluminum inhibit or retard purification. No organic compounds have been found which inhibit or retard action of activated sludge.—*R. E. Thompson.*

The Water Supply of Jerusalem. S. R. RAFFETY. J. Roy. Sanit. Inst., **48**: 181, 1927. From Chem. Abst., **22**: 288, January 20, 1928. Description of past and present supply.—*R. E. Thompson.*

Preventing Incrustation in Boilers. L. ERENYI. Brit. 265,580, February 3, 1926. From Chem. Abst., **22**: 290, January 20, 1928. Electric current of periodically varying voltage is applied to walls.—*R. E. Thompson.*

Storage of Sterile Solutions. PH. HORKHEIMER. Pharm. Ztg., **72**: 1408–9, 1927. From Chem. Abst., **22**: 302, January 20, 1928. Storage of sterile solutions discussed, notably in relation to quality of glass container and manner of closing same, as practised in Nürnberg General Hospital.—*R. E. Thompson.*

Relation Between the Characteristics of Portland Cement and the Deterioration of Concrete. J. R. BAYLIS. **I. Characteristics of Portland Cement.** Concrete, **31**: 1, 13–5. **II. Compounds in Solution During the Setting of Cement.** Ibid., 2, 23–6, 41. **III. Corrosion of Concrete.** Ibid., 3, 27–30. **IV. The Effect of Neutral Salts on Concrete.** Ibid., 4, 39–42. **V. Improving the Durability of Concrete.** Ibid., 5, 46–7, 49. From Chem. Abst., **22**: 309, January 20, 1928.—*R. E. Thompson.*

Lime-Proof Soaps, Especially Methylhexalin and Turkey-Red Oil Soaps. J. AUGUSTIN. Seifensieder-Ztg., **54**: 781, 1927. From Chem. Abst., **22**: 507, February 10, 1928. Of 100 grams of soap, 30 grams formed calcium soap in hard water; only 25 grams was lost in this way when 10 grams methylhexalin was added to the soap. While such addition does not prevent formation of

calcium soap, it holds it suspended in such finely divided state that deposition on fiber is practically prevented. This action is intensified when sulfonated oil soaps are used. Color of product, however, is dark, consistency soft and lathering power diminished.—*R. E. Thompson.*

Water in Beet-Sugar Manufacture. MAX GREVEMEYER. Gas.- u. Wasserfach, **70**: 1118–9, 1927. From Chem. Abst., **22**: 508, February 10, 1928. Amounts needed for various processes, and suggestions for economy and for disposal of waste are given.—*R. E. Thompson.*

Third Report on the Relative Corrodibilities of Various Commercial Forms of Iron and Steel. J. NEWTON FRIEND. Iron and Steel Inst., London, Carnegie Scholarship Mem., **16**: 131–51, 1927. From Chem. Abst., **22**: 373, February 10, 1928. Different commercial specimens of iron and steel have been subjected to corrosion tests over period of years. Parallel tests were run in laboratory and in "field" under natural conditions. Report gives results of salt water tests. Results prove that it is dangerous to draw conclusions about corrosion from isolated tests. Metals which showed low relative corrosion one year often showed a high one the next. Mean results of several sets of tests over long period of time usually agree fairly satisfactorily.—*R. E. Thompson.*

Theory of Metallic Corrosion in the Light of Quantitative Measurements. G. D. BENGOUGH, J. M. STUART, and A. R. LEE. Proc. Roy. Soc. (London), **116A**: 425–67, 1927. From Chem. Abst., **22**: 375, February 10, 1928. Detailed description given of method of making very accurate measurements of corrosion by means of oxygen absorption. Corrosion of zinc in water and dilute salt solutions was studied. Oxygen consumed was plotted against time and equations were developed to express curves mathematically. In the dilute solutions studied the rate of oxygen supply was not a factor determining corrosion rate. Increasing concentration of electrolyte increased corrosion.—*R. E. Thompson.*

Atmospheric Corrosion of Metals. W. H. VERNON. Bull. Brit. Non-Ferrous Metals Research Assoc., **21**: 9–21, 1927; cf. C. A., **21**: 1623, February 10, 1928. Discussion of work on atmospheric corrosion by British Non-Ferrous Metals Research Association.—*R. E. Thompson.*

Control of Corrosion—New Alloys. W. M. MITCHELL. Ind. Eng. Chem., **19**: 1253–6, 1927. From Chem. Abst., **22**: 375, February 10, 1928. Discussion of alloys in relation to corrosion resistance.—*R. E. Thompson.*

Twenty-First Biennial Report of the North Carolina State Board of Health. July 1, 1924–June 30, 1926. Bureau of Sanitary Engineering and Inspection, 62. The objectives, activities and accomplishments of the Sanitary Engineering Bureau of the North Carolina State Board of Health are very interestingly presented in this article, illustrated with numerous graphs and charts. The 238 public water supplies serving 28.37 per cent of the total State population, are under the supervision of the Bureau. Of this number, 73 are filtered, 27

are unfiltered surface and 138 are ground water supplies, serving 573,000, 67,000 and 178,000 persons, respectively. Of the 73 filtered supplies, 38 are under trained operation and laboratory control and serve over 87 per cent of the total population using filtered water.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Report of the Division of Sanitary Engineering. L. F. WARRICK. Annual Report of Wisconsin State Board of Health, 13. A summary of the work completed by the division during 1927 is given, and then followed by a brief description of such activities as investigations of water supplies and sewerage, with a more detailed account of the stream pollution control activities.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Report of the Commissioner of Health of Porto Rico for the Year ending June 30, 1926. Epidemics of typhoid fever and malaria occurred in several towns during the year. Of the 76 municipalities on the Island, 24 have both water and sewerage systems; 32 have only waterworks; one has only a sewerage system; and 19 are without either. Approximately 300,000 of the 350,000 urban population are supplied with water from public systems—132,103 with treated water. About 224,000 of the urban population are served by sewers.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

The Water Resources of Rhode Island. Report of the Commission appointed to investigate the sources of water supply for cities and towns, to the General Assembly at the January session, 1928. The report discusses the water resources of the State from the standpoint of the geologist, the chemist and the engineer. Surface supplies without purification, used by 33.9 per cent of the entire state population, filtered surface supplies, used by 62.3 per cent, and ground water supplies, used by 3.8 per cent of the total population. The physical and chemical characteristics and bacterial content of the individual public supplies are given in tabular form. Data concerning disinfection of certain of the public supplies are presented. The sanitary quality of 1,797 rural wells, as disclosed by examination, showed that 52 per cent were safe for domestic use, 23 per cent were doubtful and 25 per cent were unsafe.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Paint and Preservative Specifications for Metal Tanks. C. M. BARDWELL. Tenth Annual Texas Water Works Short School, Houston, January 23–27, 1928. Laboratory and field tests were run to find a suitable protective coating for interior of steel water storage tanks. Linseed oil base paints found to be unsatisfactory; some asphaltic base paints were found satisfactory for this service but high in cost; and coating of cement grout was found satisfactory when properly applied.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Preliminary Report of the Investigation of the Pollution of the Mississippi River in the Vicinity of Minneapolis and St. Paul. H. R. CROHURST. Unpublished report made under supervision of United States Public Health

Service in coöperation with the States of Minnesota, Wisconsin and cities of Minneapolis and St. Paul. The report contains summarized results, as monthly averages, of the chemical and bacteriological examinations and hydrometric data. Population estimates, estimates of sewered population, population equivalent to industrial wastes and other pertinent data are presented. Indications are that the sewage load in the river will increase so that objectionable conditions through the Twin Cities and as far down stream as Hastings will be of frequent occurrence in the future.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Milwaukee Metropolitan Sewerage District Problem. T. CHALKLEY HATTON. Proc. Ninth Texas Water Works Short School, January 24–29, 1927, 297. The city of Milwaukee has a population of approximately 560,000 and an area of 34 square miles, and surrounding it are 13 separate municipalities of a combined population of 80,000. The city of Milwaukee obtains its water from an intake 70 feet below the lake surface and 6,500 feet from shore. The average daily flow of sewage is about 65 million gallons and all the water that was used for drinking purposes had B. coli present, necessitating chlorination.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

The Public Works of the Ruhr Sanitary District. KARL IMHOFF. Pamphlet in German, June, 1927. The Ruhr River Sanitary District was established by a Prussian law on June 5, 1913. Its sole purpose is to prevent pollution of the Ruhr River and its tributaries. The total population contributing is about 1,300,000. Industrial wastes are contributed by coal mines, iron and steel works, tanneries, textile works, and cellulose and paper works. According to the law one-third of the cost of carrying on the work of the district is paid by the water works, since they are considered as receiving the greatest benefit.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Stream Pollution in Wisconsin. Madison, Wis. State Bd. Health, 1927, pp. 18 + 328. Experiment Station Record, U. S. Dept. of Agriculture, **58**: 6, 585, April, 1928. "This is a joint report of the Conservation Commission and the State Board of Health of Wisconsin concerning their activities in the control of stream pollution from July 1, 1925, to December 31, 1926. The data reported indicate that the discharge of industrial waste into certain streams is the only practical method of ultimate disposal in many cases and constitutes a necessary and proper use of the stream, provided the dilution is so great that there is no menace to public health nor material interference with the natural aquatic life of the stream. Data from stream pollution surveys are also included."—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Zeolitic Water Softening. RAY RILEY. Proc. Ninth Texas Water Works Short School, 139, January, 1927. A semi-technical discussion of the Zeolitic method of softening water and its applications. The two methods of water softening; namely, the lime-soda process and the zeolite process, are compared as to use, cost and results obtained. The lime-soda method is more applicable

where large amounts of water are used but when small supplies are to be treated, the zeolite method is less expensive. This method has found application to textile industries, power plants, laundries, hotels and houses. Some of the advantages are: (1) Complete removal of hardness with no "after reactions;" (2) unaffected by fluctuations in hardness; (3) occupy a small space and simple in operation.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

The Hydraulic Design of Flume and Siphon Transition. JULIAN HINDS. **Discussion.** Proc. Am. Soc. Civ. Eng., **54**: 4, 1195–1215, April, 1928. F. T. MAVIS. The flow of water through the more common types of transition sections can be calculated quite accurately by the methods described by HINDS. Occasionally there are unusual types that cannot be calculated and the studies must be carried on in the hydraulic laboratory. Description is given of various inlet and out transition models for flood diversion tunnel at Nürnberg, Germany. W. H. R. NIMMO. Describes a transition chamber in a diversion project of 450 second-feet capacity. The flume velocity of 10 feet per second is reduced to 3.5 feet per second for the canal. At full capacity there is considerable drop in the energy line passing through the transition, and it is not an efficient stilling device. When the water is turned into the empty canal it is a matter of chance as to which side the high velocity section will be deflected; but once deflected to one side, it always remains on that side. C. ROHWER. No satisfactory method for computing transition losses has yet been developed. There is doubt if the complicated inlets shown by HINDS are justified when simpler structures seem equally efficient. Observations were made on the losses of head through Venturi flumes with throat widths of from 1 to 8 feet. In calibrating under free-flow conditions, it is necessary to keep the down-stream depth of the water so low that it will not back the water into the throat of the flume.—*John R. Baylis.*

Baffle-Pier Experiments on Models of Pit River Dams. I. C. STEELE and R. A. MONROE. **Discussion.** Proc. Am. Soc. Civ. Eng., **54**: 4, 1225–33, April, 1928. R. F. EWALD. Experiments were conducted to determine the extent to which baffle-piers could be depended on to reduce the high velocities at the toes of high dams. A line of baffle-piers was attached to the bucket of the dam of the same height as the estimated maximum depth of water at the point where the velocity was greatest. The energy dispelled by the piers was small, for the depth of water required to bring the jump to the toe of the dam was approximately the same with or without baffle-piers. The necessity for artificial construction to develop the jump depends on local conditions. Usually there is no serious objection to permitting scour. The ideal method of absorbing kinetic energy is to take the water through the entire drop over perfectly smooth surfaces into cushion pools. F. W. SCHEIDENHELM. The appearance of the surface of the water flowing from the foot of a spillway is not a reliable criterion of the effect on the bed of the stream. Experiments at the hydraulic laboratory of Cornell University indicated that the height of tail-water is of great importance.—*John R. Baylis.*

Sewage Polluted Surface Waters as a Source of Water Supply. H. W. STREETER. Public Health Reports, 43: 24, 1498, June 15, 1928. "The excessive sewage pollution of surface bodies of water used as sources of water supply has begun to attain serious proportions in certain areas of the eastern and middle-western States, notably in the Ohio and Hudson River basins, and in some marginal zones of the Great Lakes, particularly at a few points located along Lake Erie, in the extreme southern end of Lake Michigan, and in some of the connecting waters as in the Detroit and Niagara Rivers. In portions of these areas water purification plants have been and are being elaborated more and more in an effort to offset increased raw water pollution. In some instances, recourse either to additional water storage or to sewage treatment measures probably will be necessary in the not distant future. In certain cases the presence of industrial wastes in sources of raw water supply is a further complicating factor, especially in the upper portions of the Ohio River and at some points along the Great Lakes." Most important among factors determining the suitability of sewage-polluted sources of water supplies are the extent of protection afforded by artificial processes of water purification and the practicability and economy of further artificial measures. Pollution chiefly consists of domestic sewage and industrial waste. Data presented show the B. coli content of the Ohio, Illinois, and other rivers to be higher in summer than in winter, but to persist longer in winter than in summer. Regarding the modifying effect of dilution, acid wastes usually produce secondary chemical reactions which may interfere with water purification efficiency. Domestic sewage and water of a diluting stream or lake form a mixture the bacterial content of which is temporarily excessive. Natural purification, with time, temperature, volume, and distance as functions, lowers this content. In an appraisal of conditions of bacterial pollution surrounding a given source of supply, full account should be taken of population groups and their respective locations on a time-distance basis. Cleaning measures to protect a supply should consider sewage from population groups immediately above the given intake. Stream burden may be greater in winter than in summer. Physically controllable factors influencing efficiency of steps in the water purification process are: retention periods provided in basins; depths and sizes of filtering material; coagulants; disinfectants; pH; and rate of flow. Physically uncontrollable factors are temperature, turbidity, and raw water bacterial content. The bacterial efficiency of filtration plants treating raw waters from the Great Lakes appears to be of a lower order of magnitude than that of similar plants treating river water such as that of the Ohio. Should this be confirmed, it would be logical to expect any standard of bacterial pollution for supplies located along the Great Lakes to be more rigid in its limiting requirements than a corresponding standard for river waters of the Ohio type. Elaboration of current processes may consist of long time preliminary storage, double stage preliminary sedimentation, sometimes aided by two stage coagulation, double filtration, and prechlorination of the raw water prior to its delivery to preliminary sedimentation basins. Sewage treatment may be complete or partial according to conditions. Cost data and curves are presented regarding these supplementary measures.—*R. E. Noble.*

New Indicating Equipment for Industrial pH Measurements. HENRY C. PARKER. Ind. Eng. Chem., **20**: 676–80, 1928. Three new potentiometers, including a field kit, suitable for making industrial pH measurements and the technique required for the use of quinhydrone and hydrogen electrodes are described. No mention, however, is made of the tungsten electrode.—*Edward S. Hopkins.*

Dissolved and Suspended Mineral Matter in the Colorado River. W. D. COLLINS and C. S. HOWARD. Ind. Eng. Chem., **20**: 746–8, 1928. Recent studies of the Colorado River show that the dissolved solids range from about 250 to 1500 p.p.m. It is possible to use this stream for irrigation if suitable drainage is provided. At times, too, it could be used for domestic supply, but the concentration of dissolved solids often exceeds the limit permissible in a public supply. Excessive, improbable storage would be necessary to produce a water having dissolved solids as low as 500 p.p.m.—*Edward S. Hopkins.*

Use of Liquid Sodium Aluminate in the Clarification of the Denver Supply. O. J. RIPPLE, G. J. TURRE and C. H. CHRISTMAN. Ind. Eng. Chem., **20**: 748–52, 1928. Better water but with slight increase in cost of coagulants has been secured at Denver by use of alum in conjunction with sodium aluminate instead of with lime. This is particularly true during periods of minimum dosage. No appreciable increase has been noted in total hardness or in alkalinity, since final effluent using either system has practically the same pH value. Charts and data tables are given.—*Edward S. Hopkins.*

Use of Exchange Silicate (Zeolite) Water Softeners in Railroad Practice. GEORGE L. BAXTER. Ind. Eng. Chem., **20**: 755–58, 1928. Zeolite treatment of certain waters on the Southern Pacific has been found less expensive than lime and soda ash softening. This is due to difference in chemical costs and to less labor being required for plant operation. As compared with untreated water, a saving in boiler repairs and fuel of $0.34 per 1000 gallons has been realized. Some foaming and priming has occurred, believed to be due to dissolving of previously formed incrustations, or to the mechanical handling of the engine by the engineer. It is thought that "more satisfactory operation of stationary and locomotive boilers" has been the result of this form of softening.—*Edward S. Hopkins.*

Municipal Water Softening at St. Louis. AUGUST V. GRAF. Ind. Eng. Chem., **20**: 758–9, 1928. Iron, lime, and alum are being used for the treatment. Sufficient lime is added to convert bicarbonate alkalinity to normal carbonate and then alum, to reduce this to about 30 p.p.m., iron and lime being used to coagulate turbidity when necessary. Hardness is reduced from about 125 to 250 p.p.m. to about 50 p.p.m. Coating of sand grains in filters has occurred with increase in effective size from 0.4 mm. diameter to 0.54 mm. diameter. Water delivered to consumer has a pH value of about 8.6.—*Edward S. Hopkins.*

Apparatus for the Micro-Determination of Dissolved Oxygen. THOMAS G. THOMPSON and ROBERT C. MILLER. Ind. Eng. Chem., **20**: 774, 1928. A description and method of analysis.—*Edward S. Hopkins.*

Kansas City Water Works Survey. Anon. Public Works **59**: 132–134, 1928. This report was made by the Kansas City Public Service Institute on the condition and operating efficiency of the department and the sufficiency and economy of construction of the new plant. The department is divided into an engineering, a collection, and an administration division. The investigators believed a reduction in the number of employees in the collection division was possible. Operation of the plant was considered good. Cost of water is high on account of the pumping required due to the topography of the city. Meters are owned by the consumers. Costs of testing and repairing meters are high because more than 30 different makes of meters are in use. Universal metering and municipal ownership of meters are recommended.—*C. C. Ruchhoft.*

Present Status of the Valuation Problem Under Recent Federal Decisions. Joseph A. Beck. Water Works, **67**: 131–133, 1928. A review of the United States Supreme Court decision in the Indianapolis Water Company case and of its application to engineering valuation estimates of public utility properties for rate making purposes is given. The rule for rate making purposes that seems to be quite definitely established is: "the present value of the land plus the present cost of constructing the plant, less depreciation, if any."—*C. C. Ruchhoft.*

New Filter Plant at Waukegan, Ill., Designed on Duplex Plan. Anon. Water Works, **67**: 97–102, 1928. The new plant with a total pumping capacity of 20 m.g.d. is designed on the duplex plan so that either half may be operated as a unit. The feature of the plant is the aeration; both primary and secondary aërators operate on the inspirator principle. The chemicals are to be added in the primary aërator which will also act as a mixing chamber. There are 10 filters each of 1 m.g.d. rated capacity. The chlorine will be applied before the water reaches the secondary aërators. From the secondary aërators the water passes through a 1000-foot channel to the 4.3 million gallon storage resevoir.—*C. C. Ruchhoft.*

Deep Well Drilling for Water in Northern Illinois. F. J. Link. Water Works, **67**: 121–2, 1928. A large number of artesian wells with depths from 1,200 to 2,700 feet and diameters of 15 to 24 inches at the top and 10 to 12 inches at the 2,200 feet depth have been drilled for municipal supplies and industrial uses in northern Illinois. With very few exceptions the water obtained is of good quality. Formerly many drilled wells in this region obtained their water from the layer of St. Peter sandstone at a depth of 800 to 900 feet but due to the large number of wells the yield of this sandstone has been diminished. Most new drilled wells tap the upper or lower Potsdam sandstone at depths of about 1,400 or 2,200 feet respectively.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

New Pumping Station that Uses Purchased Power. Anon. Water Works, **67**: 51–4, 1928. The design and construction of the new 120 million gal. per day pumping station for the Ravenswood district in Chicago is described. The water for the plant will be obtained from the Wilson Avenue tunnel

through a short new tunnel. The station will include a screen pit, pump room, transformer room, chlorination room and office. The screen pit will be equipped with two 8 by 10 feet welded monel metal screens. The pump room will contain 4 motor driven 40 m.g.d. centrifugal pumps working against a total head of 150 feet. The motors will work on the commercial power circuit through transformer equipment. Purchased electric power was chosen because of the limited space available for the plant, the distance that coal would have to be hauled from a railroad, and the residential character of the neighborhood. Chlorination equipment will include four units to use standard 100 pound containers.—*C. C. Ruchhoft.*

Seventh Annual Report of Ohio Conference on Water Purification, 1927. 66 pp. **Raw Water Chlorination at Sandusky.** O. F. SCHOEPFLE. 19–21. Brief additional data are presented regarding prechlorination at Sandusky as a means of producing filter effluent conforming to U. S. P. H. S. standard. Process is very effective except during period when water temperature is around 0°C. At such times bacteriological efficiencies are lower owing to fact that amount of chlorine which can be applied and still maintain absence of free chlorine in filter influent is materially less. Presence of free chlorine in filter influent during winter period resulted in low efficiencies due to unloading. This does not occur when temperature is higher. Average B. coli index of filtered water during whole period of prechlorination was 1.44 per 100 cc. By maintaining free chlorine in influent throughout year it is hoped to avoid unloading during winter. **Raw Water Chlorination at Warren.** PHILIP J. O'CONNOR. 21–4. Prechlorination has been experimented with as means of coping with increasing pollution of Mahoning River water. The plant is of 8-m.g.d. capacity, present consumption being 3 m.g.d. The chlorine is applied before water enters mixing chambers. Bacterial content of water entering settling basins was much lower than that of raw water, but a great increase occurred in the coagulation basins, bacterial count of filter influent being at times higher than that of raw water. B. coli content, however, was consistently reduced throughout treatment, filter effluent at all times conforming to U. S. P. H. S. standard. Secondary chlorine treatment of filter effluent rendered water practically sterile. Treatment eliminated algae growths in basins and increased length of filter runs during summer months. **Raw Water Chlorination at Akron.** J. S. GETTRUST. 24–7. Prechlorination was experimented with at Akron during February and March, 1927, in an effort to eliminate gas forming organisms previously reported on (this Journal, **16**: 671; **19**: 467). These organisms, which ferment lactose only after 24 hours' incubation, occurred in 50 per cent of 10 cc. samples of chlorinated water examined during 1925. Chlorine in amounts up to 2.23 p.p.m. was applied to water entering mixing chambers and sulfur dioxide was applied at outlet of coagulation basin to remove residual chlorine, which was as high as 1 p.p.m., contact period thus provided being 5 hours. The treatment effected considerable reduction in bacterial content of filter influent and B. coli were removed entirely, but it was not effective in reducing the gas forming organisms mentioned. Bacterial quality of delivered water was not materially changed. No benefits were observed which would justify chlorina-

tion of raw water as regular practice. In discussion, G. R. PATTON reported that prechlorination was employed at Struthers for removal of taste due to algae. Treatment of water with 0.6 to 0.8 p.p.m. chlorine in preliminary sedimentation basin providing approximately 3 days' detention has completely eliminated taste troubles. **Water Softening at Oberlin.** W. H. CHAPIN 27. Additional data given regarding softening at Oberlin (cf. this Journal, **16**: 669). Surface water is impounded and stored in reservoir, treated with lime and soda ash and stored in second reservoir having holding capacity of about 30 days. From latter the water flows to pumping station, where it is chlorinated before distribution. It was hoped that considerable recarbonation would occur during 30 days' storage, but this has not materialized. The storage, however, has effected further reduction in hardness by providing time for completion of reactions. After treatment and prior to storage, total alkalinity is about 65 p.p.m. and phenolphthalein alkalinity 35 p.p.m., while after storage these values are 45 and 23 respectively. Water is practically stable, no further reduction in normal carbonates and very slight reduction in total alkalinity being noted in distribution system. **Mechanical Control of Wash Water Application at Bellaire.** 27–9. Illustrated description of device developed by E. J. LEWIS for automatically controlling application of wash water through hydraulic valve at Bellaire, O., filter plant. Device causes valve to open and close slowly, preventing overturning of filtering material, and controls length of wash to any predetermined period. **Detection of Condenser Leakage by the Bacterial Method.** 29–30. Toronto plant of Penn-Ohio Power and Light Co. is equipped with steam driven generators and condensers, through each of which 86 million gallons of river water are pumped daily. Idea was conceived by L. W. RADMAN, plant chemist, that condenser leakage could be detected by bacterial counts on condensate, which should of course be sterile if uncontaminated by leakage of river water. Instance cited where small leaks in 6 of 9450 tubes in one condenser were detected by this method. Improbable that such extreme sensitivity could be obtained with any other method. **Automatic Altitude Valve for a Wash Water Tank.** 30. Brief description of Golden-Anderson altitude valve installed at East Liverpool plant in place of float valve which frequently did not function, allowing tank to overflow. **Should Trees be Allowed to Grow Adjacent to Impounding Reservoir.** 31. T. H. TRISTRAM reported that at Wellington an effort has been made to keep growth of trees and bushes around reservoir to minimum. With cleaning up of banks of reservoir a reduction has been noted in color of water. C. BAHLMAN stated that leaves from 4 poplar trees near reservoir at Blanchester cause black slimy deposit on reservoir bottom. J. S. GETTRUST described reforestation at Akron water supply reservoir. Trees, mostly evergreens, obtained free from State Forestry Experiment Station, will be set in rows 6 feet apart each way, or 1200 trees to acre. Upon property purchased for reservoir there were orchards containing 1000 trees. Nine thousand new trees have been set out and 4000 more are to be planted to complete orcharding program. Operation of the orchard, which requires services of horticulturist, has proved profitable investment and improves appearance of grounds adjacent to reservoir. **What Cities are Making Routine Tests of Tap Water for Comparison with the Plant Tests, and What do These**

Tests Show? 32. At Cincinnati there are 2 large open reservoirs on the distribution system. Part of city is supplied with water direct from filtration plant. Bacterial count and B. coli index are invariably higher in samples collected in down-town section than in samples collected at plant or from that part of system supplied directly from plant. At Toledo, samples collected from city taps showed higher bacterial content than plant sample and B. coli were more numerous. Reservoirs on system are covered and increase cannot be explained. Condition has been remedied by introducing chlorine at 2 points, at plant and at high service pumping station 2 miles distant. As total quantity of chlorine applied is same as with single application, treatment is not in any sense to be considered double chlorination but rather split chlorine treatment. Since adoption of this method city tap samples have had B. coli index of zero. At Cleveland, B. coli index of tap water is greater than of water leaving plant. Some of reservoirs on system are open. D. H. RUPP stated that samples of tap water collected at East Liverpool during periods when raw water B. coli index was high had lower B. coli index than plant effluent. This is ascribed to longer period of contact with chlorine. **What is the Proper Size for the Inverted Tube in the Fermentation Tests?** 32. It appeared to be consensus of opinion that size of tube had very little effect on percentage of gas produced. **Can Crushed Stone or Slag be Used for Supporting Medium for Rapid Sand Filters?** 33. R. W. FURMAN stated that some small softening installations in Toledo employed crushed stone over underdrains. Crushed brick was used in one case. Only objection was that smaller sizes could not be graded satisfactorily on account of packing. For larger sizes, crushed stone had been used with good results in plants employing lime softening. No difficulty in washing these filters had been experienced. **Description and Operating Results of the Water Purification and Softening Plant at Piqua.** J. M. MONTGOMERY. 38–46. The 5-m.g.d. purification and softening plant of Piqua, treating water from Swift Run Lake, consists of nozzle aërators, mechanical mixing tanks providing detention period of 33 minutes, Dorr clarifier providing detention period of 80 minutes, settling basins of capacity equal to 2 hours' flow, carbonation chambers, coke burner and scrubber, four 1.25-m.g.d. rapid sand filters, chlorination equipment, and 0.5-m.g. clear well. Alum and lime are applied to water entering mixing chambers, former through Gauntt dry feed machine and latter by means of BROWNING feeder and slaker. Latter, designed by OREN BROWNING, chief operator, is described and illustrated. Sludge removal by Dorr clarifier has averaged 97 per cent, 0.75 per cent of water entering plant being wasted in removing sludge. In softening as ordinarily practiced, the theoretical limit of 17 p.p.m. of carbonate hardness cannot be nearly attained due probably to formation of complex magnesium salts. At Piqua it has been found that excess lime treatment can be effectively employed to increase softening efficiency. Sufficient lime is added to produce caustic alkalinity of 40 p.p.m., which precipitates magnesium as hydrate. After settlement the water is recarbonated until total alkalinity minus twice the phenolphthalein alkalinity equals approximately 5. After filtration the water has total alkalinity of 20 to 25 p.p.m., consisting of 15 to 20 p.p.m. normal carbonates and 5 p.p.m. bicarbonates. The total hardness is reduced from 260 to 50 to 55 p.p.m. without use of sodium carbonate. With

ordinary lime treatment the total hardness would be 80 to 85 p.p.m. This additional softening is effected at cost of 2.5 cents per p.p.m. per million gallons compared with 4 cents for ordinary lime treatment. Cost of soda ash treatment would be 12 cents per p.p.m. per million gallons. Carbon dioxide used is approximately same as in ordinary lime treatment, only sufficient being added to convert caustic alkalinity to normal carbonate alkalinity, whereas usual method is to convert caustic and carbonate alkalinity to bicarbonates. J. Q. McGUIRE, in reporting experience at Greenville with Piqua method of treatment, stated that lime and soda ash are added to causticity of 40 p.p.m., and then carbon dioxide as at Piqua. Total alkalinity of filtered water is about 35 p.p.m. and incrustants about 55 p.p.m. Total hardness of 90 p.p.m. is produced at no greater cost than with former method when filtered water hardness averaged 120. pH is 8.4. Improvement has been noted in character of floc and its settling qualities. Filter runs have increased. P. D. WAGGONER stated that Piqua method had been employed at Delaware for 3 months. Filter runs have been increased 20 per cent. Major portion of precipitate settles as soon as water enters settling basin. Treatment enabled use of less alum during recent turbid water period than was previously required.

Description of Operating Results of the Barberton Water Purification Plant. H. T. CAMPION. 47–59. The 4-m.g.d. plant put in service at Barberton in June, 1926, treating water from impounding reservoir on Wolf Creek, consists of nozzle aërators, mechanical mixing basins providing detention period of 14 minutes, coagulation basins of capacity equivalent to 3.4 hours' flow, four 1-m.g.d concrete rapid sand filters, chlorination equipment, and clear well. Prechlorination has been found effective in increasing filter runs during summer months when algae are numerous. Manganese, in amounts up to 1.25 p.p.m., derived from decaying vegetation in new reservoir, has placed an additional burden on the filter plant. Total manganese was determined by persulfate method and manganic manganese by its reaction with o-tolidin reagent. Proportion of manganic manganese was extremely irregular. Oxidation continued in samples standing in laboratory, being complete in 3 to 5 days, i.e., when pH reached 8.0 due to loss of carbon dioxide. Addition of copper sulfate prevented oxidation, presumably by killing organisms effecting change. Chlorine in amounts up to 10 p.p.m. failed to oxidize the manganese. Hydrogen peroxide effected complete oxidation, reaction being hastened by raising pH with lime. This method was employed in determining total manganese with o-tolidin. Lime treatment followed by coagulation with alum or iron will precipitate the manganese. With sufficient lime to render water caustic, all the precipitate settles in basins, but with lower amounts of lime some of floc is carried on to filters, and, with accompanying growths of slime and manganese bacteria, cements filter sand causing short runs. Raw water chlorination will prevent these growths to a large extent, allowing longer runs. The manganese is very difficult to remove from the filter. A tremendous increase occurs in nitrite content during filtration. The significance of this is not apparent. D. E. DAVIS reported successful removal of manganese from supply containing 1 p.p.m. by zeolite softening plant. There was no evidence of manganese encrustation of zeolite grains. W. DONALDSON stated

that supply of Lowell, Mass., derived from shallow wells, contained 6 p.p.m. manganese. Treatment comprises aëration, sedimentation, and slow sand filtration. In initial operation of plant manganese penetrated to underdrains. By limiting aëration to oxygen saturation of only 50 per cent, considerable success was obtained in precipitating manganese before it reached filter bottom. North Little Rock, Ark., supply, containing 3 p.p.m., is made satisfactory by merely aëration and sedimentation. **Final Report on Double Coagulation Studies at Cincinnati.** CLARENCE BAHLMAN and E. B. EVANS. 60–3. (Cf. this Journal, **19**: 462, 465). Final report is made upon double coagulation, which has been subject of experimentation over period of sixteen months at Cincinnati filter plant. Use of alum as primary coagulant has been found more satisfactory than iron sulfate treatment of equal cost. Saving in secondary chemicals, iron sulfate and lime, has not equalled cost of more expensive primary coagulant, the additional cost of double coagulation having averaged 86 cents per million gallons. Filter runs have been increased on an average by 31 per cent, and wash water reduced 18 per cent. This effect was confined solely to warm weather period, during which time increase in runs was 30 to 65 per cent and wash water reduction 25 to 40 per cent. Double coagulation has materially improved quality of filter effluent and has enabled uniform production of chlorinated water of standard quality even with extreme raw water pollution. Filter effluent is not of standard quality under normal operating conditions employing double coagulation, but if lime dosage is increased to give 1 to 3 p.p.m. caustic alkalinity a coli-free effluent results. This enabled chlorination to be discontinued during period when phenol pollution was present, giving rise to taste with chlorine. F. E. SHEEHAN of Portsmouth confirmed reported advantages of double coagulation. Average chemical cost is about $2 per million gallons. Filter runs average 30 hours the year around. B. coli content is reduced from 5 to 10,000 in raw water to 2 to 3 per 100 cc. in filtered water. When phenols are present in raw water, increasing lime dosage to maintain 2 to 3 p.p.m. causticity reduces B. coli content of filter influent to less than 10 per 100 cc., permitting chlorination to be dispensed with. **Discussion of the Operating Results of the New Piqua Water Softening Works.** CHAS. P. HOOVER. 64–5. Results at Piqua with excess lime are discussed and the history of carbonation reviewed. At Columbus during times of flood, when an excess of lime is required, the water is toxic to gold-fish. This has always been assumed to be due to the excess lime added, but recent observations and experiments have led to conclusion that trouble is due to residual alum in water at times when excess lime is employed. It is proposed to carbonate water after settlement to reduce pH to point where complete precipitation of alum will be assured. It is believed to be better practice in treatment of flood waters to add alum first, then follow with lime-soda treatment after bulk of precipitated alumina and entangled mud has been settled out. **The Manganese Removal Problem at Barberton.** R. D. SCOTT. 66. Brief data are given regarding manganese content of some of raw water supplies in Ohio, together with data on total and manganese encrustation of filter sand at several plants. Zeolite filtration offers possible means of manganese removal.—*R. E. Thompson.*

Resistance to Flow in Floodway of St. Francis River. CHAS. E. RAMSER. Eng. News-Rec., **100**: 541–2, April 5, 1928. Details given of measurements made early in 1927 of flow through standing timber in St. Francis River floodway in northeastern Arkansas, where conditions are such as would prevail in considerable parts of relief channels advocated for preventing damage from floods on Missippi River.—*R. E. Thompson.*

Quicksand Tunnel Timbered from Needle Beam. S. H. MURDOCK. Eng. News-Rec., **100**: 550–3, April 5, 1928. Illustrated description of construction of 4000 feet of 3 ring brick masonry sewer tunnel, almost entirely in quicksand, in Cleveland.—*R. E. Thompson.*

Water-Borne Typhoid at St. Leonard, N. B. Eng. News-Rec., **100**: 555, April 5, 1928. Pollution of water supply of St. Leonard by typhoid sufferers in family living on catchment area is held responsible for outbreak in village which resulted in 200 cases and 7 deaths. Typhoid in family responsible believed due to temporary use of polluted water from St. John River. Chlorination has been recommended.—*R. E. Thompson.*

Low Leakage from 14-Ft. Butterfly Valve Under Pressure. Eng. News-Rec., **100**: 525, March 29, 1928. Butterfly valve, designed to withstand head of 46 feet, on Lake Chelan hydro-electric development in Washington showed leakage past seat rings of only 2 gallons per minute under full pressure.—*R. E. Thompson.*

ABSTRACTS, SUB-COMMITTEE NO. 9

JOINT RESEARCH COMMITTEE ON BOILER FEEDWATER STUDIES

The Most Important Aspects in Boilermaking for the Prevention of Boiler Cracking (Die bei der Kesselherstellung wichtigen Gesichtspunkte zur Vermeidung von Kesselschaeden). W. AREND. Zeit. des Bayerischen Revisions-Vereins (Munich), **32**: 11, 12, and 13, June 15, 30 and July 15, 1928, pp. 129–132, 147–150, and 160–162, 20 figs. Four causes are listed for boiler failures: defective material; faulty workmanship in manufacture of boiler; thermal operating effects; and effects of feedwater (corrosion); progress in boilermaking is fundamentally dependent upon control of materials under influence of high temperatures.

Treatment of Feedwater (Tratamiento del agua de alimentacion). S. W. PARR and F. G. STRAUB. Sugar, **30**: 7, July, 1928, pp. 337–338. Translated abstract of paper presented at Midwest Power Conference, previously annotated.

Feedwater and Materials Used in Boiler Construction (Ueber die Schutzwirkung von Natriumsulfat bei der Einwirkung von Laugen und Salzen auf Flusseisen unter Hochdruck). E. BERL and F. VON TAACK. Archiv fuer Waermewirtschaft u. Dampfkesselwesen (Berlin), **9**: 6, June, 1928, pp. 165–169, 20 figs.

partly on supp. plate. Researches at Darmstadt Technische Hochschule on effect of alkalies and salt on iron, especially at high temperatures and pressures; show that while excess of alkalinity in water is dangerous at high pressure, iron is also attacked by absolutely pure water; sodium sulphate is of great value as safeguard, and should be added to feedwater in high-pressure boilers.

The Degasification of Feedwater (Entgasung des Speisewassers). SCHLICKE. Waerme (Berlin), **51**: 20, May 19, 1928, pp. 373–374, 1 fig. Description of process for removal of injurious gases at 100 to 120°C.; its use in industrial power plants.

Isolated Makeup System Proves Advantageous. A. A. WOODWARD. Power Plant Eng., **32**: 12, June 15, 1928, pp. 666–668, 2 figs. Feedwater makeup is delivered to system from separate boiler in form of steam at header pressure; arrangement automatically takes care of emergencies; new system requires little additional equipment.

Boiler Feed-Water Problems. S. T. POWELL. Mech. World (Manchester), **83**: 2161 and 2162, June 1 and 8, 1928, pp. 403–404 and 422. June 1: Degree of purification desired depends upon operating conditions; removal of suspended solids; filters; chemical softening; zeolite water softeners; evaporators; deaerators. June 8: Continuous blowdown systems; electrolytic scale-prevention appliances; internal treatment priming and foaming. Paper presented before American Society of Mechanical Engineers.

Boiler Feed Water Treatment in the Southwest. Elec. World, **91**: 25, June 23, 1928, p. 1340. Tabular data regarding conditioning of boiler feedwater in ten representative generating stations.

Feed Water for World's Largest Boilers Receives Zeolite and Acid Treatment. ALFRED H. WHITE, J. H. WALKER, EVERETT P. PARTRIDGE and LEO F. COLLINS. Power, **66**: 90–4, 1928; cf. C. A. **21**: 3096. Chemical Abstracts, 22: 12, p. 2224. June 20, 1928. The Beacon Street heating plant of Detroit, supplying steam for heating in the business district, contains 12 boilers each of 41,500 square feet of heating surface. The city water used contains free CO_2 1.8; SiO_2 6.4; Fe_2O_3 2.0; Ca 25.7; Mg 7.3; HCO_3 75.6; CO_3 0.0; SO_4 31.1; Cl 7.7 and solids by evaporation 121.0 p.p.m. The high alkalinity resulting from zeolite treatment is corrected by addition of 35 p.p.m. of H_2SO_4. The pH values are recorded in the storage reservoir and as the water leaves the feedwater heater. This amount of acid neutralizes about one-half the total $NaHCO_3$ present. The pH is 6.5 before deaeration and 8.5 after. Continuous blowdown through a heat exchanger is satisfactory. After eight months' operation the tubes were clean, there were no tube burnouts and no serious corrosion.

Boiler Water Treatment at the Sons of Gwalia, Limited. V. T. EDQUIST. Instn. Min. and Met. Bul. (Lond.), **285**: June, 1928, pp. 7–8. Author's reply

to discussion of paper previously presented and annotated from Chem. Eng. and Min. Rev., November 5, 1927; lime-soda treatment rejected because of experience with sodium sulphate in Babcock boilers; barium salts too costly.

Lime and Soda Treatment of Feed Water. E. M. PARTRIDGE. Power **67:** 507–9, 1928; Chemical Abstracts, **22:** 12, June 20, 1928, p. 2224. Partial softening with lime and soda may increase corrosive properties and result in the formation of a scale which is harder, though less in amount than is formed from untreated water. Hence complete softening is important.

Purification and Treatment of Feed Water. S. T. POWELL, Power Plant Engineering, **32:** 24–6, 1928. Chemical Abstracts, **22:** 12, June 20, 1928. pp. 2222–3. Innovations within recent years are: (1) continuous blow down where solids concentrate rapidly and where there is a marked tendency toward priming and foaming, (2) electrolytic scale and corrosion-prevention systems, (3) acid feeding equipment to inhibit embrittlement of metal, (4) deaerators, and (5) deaerating heaters.

Modern Treatment of Supplementary Feedwater for Steam Power Plants (Die neuzeitige Aufbereitung von Zusatzspeisewasser fuer Dampfkraftanlagen). BALCKE. Waerme (Berlin), **51:** 23 and 24, June 9 and 16, 1928, pp. 411–416 and 430–435, 20 figs. Author discusses properties of raw supplementary water; disadvantages of mechanical process; modern evaporation method for vacuum, low and high pressure; thermochemical treatment of large amount of supplementary water; degasification for soft chemically pure water.

Treatment of Evaporator Feed Water. T. A. SOLBERG. Power, **67:** 26, June 26, 1928, pp. 1154–1155. It is felt that there should be no opposition to chemical treatment of evaporator feedwater in view of advantages to be gained; treatment must be reasonably cheap as well as effective; principal advantage is prevention of scale formation; in evaporator it is believed that scale can be prevented with proper control of feedwater condition by using some chemical such as sodium silicate and using constant blowdown (or constant brining) to keep concentration of scaleforming salts below that which will cause scale.

Utilization of Heat for the Preparation of Boiler Feed Water. H. BALCKE. Gosundh. Ing., **51:** 209–16, 1928. Chemical Abstracts, **22:** 11, June 10, 1928, p. 2018. Tests were carried out with Fe plates suspended in water solutions of various salts. These determinations were made in a small boiler which is illustrated. The formation of scale due to the various salts which cause hardness in water is shown in a series of photomicrographs. The first series of pictures is the result of experiments with water whose sulfate concentration is 3 times its carbonate concentration and to which Fe and silicates have been added. The test pieces first showed a deposit of rhombohedral needles of $CaCO_3$. By further evaporation $MgCO_3$ separates. With continued scale formation $CaSO_4$ is deposited in blunt broken up needle or broad lamellar forms. If the $CaCO_3$ is deposited in larger amounts the deposition of $CaSiO_3$

takes place at the same time. The boiler tubes become coated with a thin layer which is imprevious to the transfer of heat. If the amount of $CaCO_3$ is slight pure silicates separated in roset and pisiform formations. Photomicrographs of O and CO_2 corrosion are shown. With O the action is local and considerable pitting takes place. With CO_2 the metal appears to become porous and white deposits of $CaCO_3$ are visible. Cl in small quantities is harmless but in high concentrations it is very active. These tests show that a feed water should be free of scale-forming constituents and dissolved O. Since most plants return their condensate as feed water it is highly advantageous to use distilled water for re-placing the loss within the plants. Various evaporating and heat exchanging systems for this purpose are shown and described.

Boiler Corrosion and Pitting. Boiler Maker, **28**: 7, July, 1928, pp. 191–193. Committee sent inquiries to 17 railroads having number of locomotives of 22,392; replies to inquiries may have been considered as representative in respect to boiler corrosion and pitting; effect of trouble and extent of preventive measures; pitting resistance of various boiler metals; progress as to control of corrosion and pitting.

Boiler Corrosion and Pitting. Ry. Jl., **34**: 7, July, 1928, pp. 26–28. Committee report before Master Boiler Makers Association; inquiries sent to 17 railroads having total number of locomotives of 22,392; comparison of conditions on pitting and non-pitting territory; effect of trouble and extent; preventive measures; pitting resistance of various boiler metals; progress as to control of corrosion and pitting.

Boiler Water for Locomotives. G. Hearn. Ry. Engr. (Lond.), **49**: 583, August, 1928, pp. 301–302. Instructive notes on feedwater, which treat subject from standpoint of locomotive engineer and give classification of value; expense of bad water supply; solids source of trouble; danger of mixing water; "soft" and "hard" water definitions; advantageous use of feedwater heater.

A. C. F. I. Feed-Water Heater. Ry. Engr. (Lond.), **49**: 582, July, 1928, pp. 267–269, 5 figs. This apparatus has been fitted to locomotives of 4–4–2 and 4–6–0 types on L. N. E. R.; apparatus comprises heater consisting of two cylindrical tanks communicating with each other by means of pipe; exhaust steam is admitted from blast pipe into mixing chamber of feed heater through steam regulator.

The Corrosion Problem. C. H. Koyl. Boiler Maker, **28**: 7, July, 1928, pp. 193–195. Three known and proven methods of preventing pitting of locomotive boilers all work on same principle, which is explained; explanation of ionization; lime-soda process; use of open feed-water heaters; metallic-arsenic method of preventing pitting.

Preventing Corrosion by Water Treatment, Deaeration, Deactivation. H. T. Hall. Domestic Eng. (Chicago), **124**: 2, July 14, 1928, pp. 29–32, 2 figs.

Some peculiarities of corrosion; water treatment, deaeration, deactivation are three distinct methods of treatment which have been developed for protecting pipe systems against corrosion.

Corrosion in Steam Plants from Boiler Furnace to the Utilization of Steam (Korrosionserscheinunger in Dampfkraftenlagen von der Feuerung bis zur Dampfverwertungsstelle). WINTERMEYER. Feuerungstechnik (Leipzig), 16: 10, May 15, 1928, pp. 112–115, 3 figs. Discussion of causes of corrosion; influence of firing system; preventive measures.

An Electrical Salinometer for Marine Water-Tube Boilers. Mar. Engrs. and Motorship Bldr. (Lond.), 51: 610, June, 1928, pp. 215–216, 4 figs. Crockett apparatus, used on several recent Naval and mercantile vessels, is described; requirements to be met by salinometer for feed system of boilers; instrument consists essentially of detector cell, through which water under test flows continuously; temperature compensator, and indicating or measuring instrument.

Thermal Energy of the Ocean, Claude-Boucherot Process (L'énergie thermique des oceans, le procédé Claude-Boucherot). A. TROLLER. Nature, (Paris), 2786, June 1, 1928, pp. 504–508. At depth of 1000 m., there are large quantities of water at temperature 20 deg. lower than at surface; by conducting this water to surface it can be utilized in connection with warm surface water for steam engines or in production of motive power; how this cold water can be raised to surface; utilization for water softening and for refrigeration.

The Value of Water in Textile Mills for Purposes Other Than Water Power. C. T. MAIN. Am. Soc. Mech. Engrs.—Textile Div. Paper for mtg., May 22, 1928, 5 pp. Full text paper previously annotated from Textile World, May 26, 1928.

Apparatus for the Micro-Determination of Dissolved Oxygen. T. G. THOMPSON and R. C. MILLER. Indus. and Eng. Chem., 20, 7, July, 1928, p. 774, 1 fig. Description of apparatus designed to determine dissolved oxygen in water when only small quantities of sample are available; used in laboratories of University of Washington. Portion of paper presented before Ecological Society of America.

Economy in Spite of Heavy Turbidity. A. MILNE. Water Works Eng., 81: 16, August 1, 1928, pp. 1107–1108 and 1120, 5 figs. Water condition creates serious problem; tests employed to insure purity; conditions of heavy turbidity encountered in water suuply; description of operation of and economy effected in St. Catherines' plant; unusual local water-purification conditions; heavy turbidity encountered; daily analysis of water; operative costs.

Water Softening Pays in the Oil Fields by Cutting Repair Costs. J. POWER. Mat. Petroleum News, 20: 29, July 18, 1928, pp. 33–35, 2 figs. Soft water saves repair expense and time of oil drilling; zeolite process recommended for clear

hard well water; turbid water from streams or ponds usually best handled by lime-soda ash process; Gypsy Oil Company plant on North Canadian River in Seminole district, Oklahoma, to treat 12,000 barrels of water daily at operating cost $712.50 per month, with plant cost less than $4000; zeolite plants of same capacity cost of $12,000 to 15,000.

A Small-Scale Filter for Water Softening (Ein Kleinfilter zur Wasserenthaertung). E. QUITMANN. Gesundheits-Ingenieur (Munich), **51**: 21, May 26, 1928, pp. 340–342. Describes Elektrolux-Natrolith zeolitic filter; its efficiency in softening and removal of iron, manganese, etc.

Municipal Water-Softening at St. Louis. A. V. GRAF. Indus. and Eng. Chem., **20**: 7, July, 1928, pp. 758–759. Description of methods used; hardness of river water varies from 126 to 257, average 177 p.p.m., and reduction from 43 to 105, average 75 p.p.m.; reduction per grain of 85 per cent lime per gallon varies from 7.5 to 20.4, average, 14 p.p.m.; amount of lime used varies from 1 to 7, average 5.4 grains per gallon.

A Photoelectric Turbidity Meter (Ein photoelektrischer Truebungsmesser). L. W. HAASE and H. THIELE. Gas-und Wasserfach (Munich), **71**: 18, May 5, 1928, pp. 414–417, 4 figs. Report from chemical division of Prussian Institute of Hygiene, in Berlin-Dahlem, discussing development of methods of water-turbidity determinations and describing experimental laboratory apparatus, consisting of selenium cell and galvanometer, for precise measurements of water turbidity.

Notes on Water Purification (Notas sobre a purificacao das aguas). S. R. DE BRITO. Revista Brasileira de Engenharia (Rio de Janeiro), **15**: 5, May, 1928, pp. 165–167. Author calls attention to three principal characteristics of drifting sand filters and compares advantages, from economic point of view with those of stationary sand filters; in second note refers to economy realized with lime and aluminum sulphate in water treatment, through determination of ionic hydrogen; corrosion of pipes avoided. Abstracts from paper submitted to Hygienic Congress in 1927.

Algal Control of Filter Basins, Cannon City, Colorado, Water Works. A. W. STEDMAN. West Constr. News, **3**: 11, June 10, 1928, pp. 377–378, 3 figs. Importance of treating municipal water supplies for control of growth of microscopic organisms; as remedy for objectionable conditions, hydrated lime, iron sulphate and copper sulphate are used.

Control of Algal Growths in the Water Storage Reservoirs of Los Angeles. C. WILSON. West Constr. News., **3**, 11, June 10, 1928, pp. 355–356, 2 figs. Definite opinions regarding use of copper sulphate; angle-iron booms have been provided forward and aft on motor launch to support sacks of copper sulphate; treat in one day lakes having area of 800 acres, applying four tons of chemicals.

The New Iron-Removal Plant of the Water Works of Lund (Lunds nya avjarningsverk). V. JANSA. Teknisk Tidskrift (Stockholm), **58**: 21, May 26, 1928, (Vag-och Vattenbyggnadskonst) pp. 62–68, 13 figs. Description of largest plant of its kind in Sweden, consisting of 3 units, each with capacity of 25 pounds and filtering speed of 120 m. per day.

Treatment of Water-Supply for Iron Removal. E. V. PEDERSEN. Am. City, **39**: 1, July, 1928, pp. 126–127. Treatment of water for removal of iron has three distinct and equally important steps; aëration; coagulation; filtration; operation and maintenance of plant; other difficulties.

Report on London Waters. A. HOUSTON. Engineer (Lond.), **145**: 3781, June 29, 1928, pp. 708–709. Review of annual report to Metropolitan Water Board on results of chemical and bacteriological examination of London waters, dealing with year of 1927; chlorination of Thames River water; chlorination of New River; prefiltration waters; Barn Elms experiments; Walton Works. See editorial comment, p. 716.

The Physical-Chemistry of Demanganization of Drinking Water (Die physikalisch-chemischen Vorgaenge bei der Entmanganung von Trinkwasser). J. TILLMANS, P. HIRSCH and H. GROHMANN. Gas-und Wasserfach (Munich), **71**: 21, May 26, 1928, pp. 481–487. Second report from nutrition department of University of Frankfurt on further experiments on absorbing efficiency of pyrolusite; factors affecting absorbing capacity of pyrolusite of hydrogen peroxide. (To be concluded.)

The Physical Chemistry of Demanganization of Drinking Water (Die physikalisch-chemischen Vorgaenge bei der Entmanganung von Trinkwasser). J. TILLMANS, P. HIRSCH and H. GROHMANN. Gas-und Wasserfach (Munich), **71**: 22, June 2, 1928, pp. 515–519. Experimental study of purely chemical oxidation of bivalent manganese; microörganisms aiding in demanganization. (Concluded.)

Taking Corrosion Out of Catskill Water. W. W. BRUSH. Water Works Eng., **81**: 13, June 20, 1928, pp. 913–914, 2 figs. Experiments of New York Water Department to effect result; water now especially corrosive to cast-iron hot-water pipes; most desirable treatment; cost of treatment; experiments to determine material.

NEW BOOKS

Water Purification. JOSEPH W. ELLMS. Second edition, 594 pages, 160 cuts, 1928. Published by McGraw-Hill Book Co. The first edition, published in 1917, was a valuable addition to our library on the filtration of water supplies. It gave the first comprehensive treatise on this subject. Appearing as it did in the midst of rapid developments in water treatment, it was evident that the book could not long supply our needs without revision. That the author has taken time to bring it up to date deserves the commendation of all

water purification engineers. The first edition has served its purpose well. It contained a vast amount of information greatly needed by those whose duty it was to design water purification plants. The history of the development of improved water supplies, classification of natural waters, water borne diseases, and the effect of improved water supplies on the health, were briefly discussed in the first edition. This material, with minor additions, has been retained in the second edition. Such subjects as sedimentation, slow sand filtration and rapid sand filtration are discussed in detail, and while largely the same as in the first edition there are a few additions that bring it up to date. The chapters on control and regulating devices, equipment for handling and applying chemicals, power plant equipment, etc., cover the subjects very well. The data on rates of filtration and operating costs have been brought up to date, and a new chapter on hydrogen ions has been added. The chapters on disinfection and the removal of dissolved mineral matter give adequate treament of these subjects. The book deals largely with rapid sand filtration, and justly so, for this is the prevailing practice in America. There is a little more of the descriptive matter in the first edition that could have been left out of the second edition to advantage, and there are a few subjects not adequately discussed in either edition. The space given to cost records prior to 1916 seems excessive. Chlorine is used almost exclusively in this country for disinfecting water supplies, but the space given to ozone and to ultra violet light might lead some to conclude that they are used quite extensively. Very little space was given to mixing basins in the first edition and this was not extended as much as it should have been in the second edition. One might conclude that the hydraulic jump is used quite extensively and that it is just as good a flocculating device as the more commonly used mixing channels. The purpose of the jump is to mix the chemicals with the water quickly and it is not a flocculating device. It accomplishes within a few seconds approximately what is accomplished in a mixing channel within the first two or three minutes. Prolonged agitation by passing the water through mixing channels or by stirring after passing the hydraulic jump is just as essential for flocculating the coagulant as it is for any other mixing device, though the author does not so state. Some of the readers not well versed in chemistry might form the conclusion that colloids have mysterious powers that are capable of accomplishing remarkable things in a filter plant. As a matter of fact the surface of a solid particle which is so small that we refer to it as being a colloidal particle probably is not greatly different from that of the surface of larger particles. The importance of surface films on sand grains as an aid to filtration appears to be overstressed, especially for rapid sand filters. Clean sand the first time used will remove the coagulated matter from water nearly as effectively as sand that has been in a bed for some time. In some instances the text does not refer to the figures and as several authors are mentioned it is difficult to know whom to credit with the data shown in the figures. This is especially true for the curves in Chapter XXVIII. A few of the paragraphs in certain chapters discuss material almost foreign to the chapter heading. It is believed that the removal of manganese at Baltimore by the iron and lime treatment should have been mentioned. It is also believed that the device for observing the clarity of the filtered water at Baltimore and at

several other plants should have been mentioned. Much might be said in praise of the book. The subject is a broad one and it has required much time to bring together such a vast amount of excellent material. To arrange it as it has been done without leaving out more of the important things is remarkable. The book is well illustrated and the descriptive matter in most instances is easily understood. It will likely remain the leading book on the design of water purification plants for years to come.—*John R. Baylis.*